Rhodium(III)-Catalyzed Regioselective C(sp^2)-H Activation of Indoles at C4-Position with Iodonium Ylides

Fuhai Wu,*[a] Lin Xiao,[b] Hui Xie,[b] Shao-Yong Chen,[b] Jia-Ling Song,[b] Yi-Chuan Zheng,[b] Yan-Zhi Liu,[b] Shang-Shi Zhang*[b]

[a]*School of Engineering, Guangzhou College of Technology and Business, Guangzhou, 510006, P. R. China.*
[b]*Center for Drug Research and Development, Guangdong Pharmaceutical University, Guangzhou, 510006, P. R. China.*

**Email: zhangshangshi@gdpu.edu.cn.*

Supporting Information

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1. General information

Unless otherwise noted, all reactions were carried out at room temperature under an atmosphere of nitrogen with flame-dried glassware. If reaction was not conducted at room temperature, reaction temperatures are reported as the temperature of the bath surrounding the vessel unless otherwise stated. The dry solvents used were purified by distillation over the drying agents indicated in parentheses and were transferred under nitrogen: THF (Na-benzophenone), 1,2-dichloroethane (CaH_2), dichloromethane (CaH_2). Anhydrous CF_3CH_2OH, CH_3CN, DMF and MeOH were purchased from Acros Organics and stored under nitrogen atmosphere. Commercially available chemicals were obtained from commercial suppliers and used without further purification unless otherwise stated.

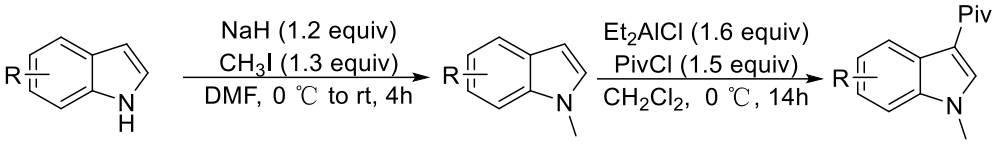
Proton NMR (^1H) were recorded at 400 MHz, and Carbon NMR (^{13}C) at 101 MHz NMR spectrometer unless otherwise stated. The following abbreviations are used for the multiplicities: s: singlet, d: doublet, t: triplet, q: quartet, m: multiplet, br s: broad singlet for proton spectra. Coupling constants (*J*) are reported in Hertz (Hz).

High-resolution mass spectra HRMS-ESI (Quadrupole) were recorded on a BRUKER VPEXII spectrometer with EI and ESI mode unless otherwise stated.

Analytical thin layer chromatography was performed on Polygram SIL G/UV_{254} plates. Visualization was accomplished with short wave UV light, or $KMnO_4$ staining solutions followed by heating. Flash column chromatography was performed using silica gel (200-300 mesh) with solvents distilled prior to use.

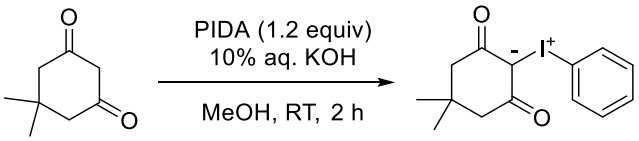
No attempts were made to optimize yields for substrate synthesis.

2. Synthesis of substrates 1[1] and 2[2]



Methyl-1*H*-indole: NaH (0.48 g, 24.0 mmol) was slowly added into the solution of indole (2.34 g, 20.0 mmol) in DMF (10.0 mL) at 0 ºC. The heterogeneous mixture was stirred at 0 ºC for 10 min and 1 h at room temperature. The mixture was then cooled to 0 ºC and then iodomethane (1.6 mL, 26.0 mmol) was added. After 4 h, the reaction mixture was cooled to 0 ºC, quenched with saturated NH_4Cl (40.0 mL) and water (100.0 mL). The organic phase was extracted by EtOAc and dried over anhydrous Na_2SO_4. The product was obtained by column chromatography on silica gel (PE: EA 80:1, yellow oil, 2.35 g, 90 %).

2,2-dimethyl-1-(1-methyl-1*H*-indole-3-yl) propan-1-one: To a CH_2Cl_2 solution of indole derivative was added Et_2AlCl (1.6 equiv) at 0 ºC. The mixture was stirred at 0 ºC for 1.5 h. To this solution was added dropwise a CH_2Cl_2 solution of PivCl (1.5 equiv) at 0 ºC. The resulting solution was stirred at 0 ºC for 12.5 h, and pH 7 aqueous buffer solution was added to quench the reaction, Then the mixture was extracted with CH_2Cl_2 and dried over Na_2SO_4. The crude product was purified by chromatography on silica gel (PE: EA 8:1).



In a 100 mL oven dried reaction tube with a magnetic stir bar, 5,5-dimethylcyclohexane -1,3-dione (5.0 mmol,1.0 equiv) and MeOH (15 mL) was subjected and kept the solution at RT. Then, 10 mL of 10%aq. KOH solution was added to the reaction mixture at RT. The tube was capped with septa. Further, iodoxybenzene diacetate (6.0 mmol, 1.2 equiv) was dissolved in 20 mL MeOH and slowly added to the above reaction mixture via syringe. The resulting mixture was stirred at room temperature for the period of 2 h and evaporate the solvent under reduced pressure, quenched with saturated NaCl (10.0 mL). Then, the mixture was extracted with CH_2Cl_2 and dried over Na_2SO_4. The product was obtained by recrystallization of dichloromethane and petroleum ether. (White solid, 1.5 g, 88%)

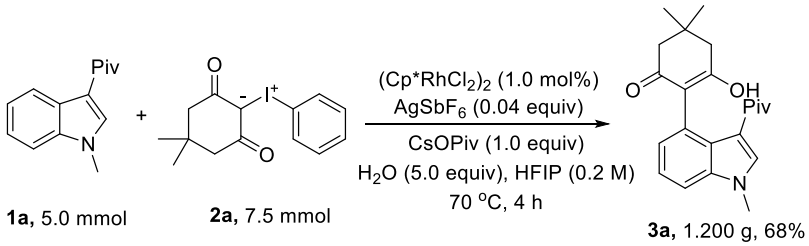
3. General procedure of product synthesis

General procedure A

In an oven-dried Schlenk tube under air, a mixture of indole substrates **1** (0.2 mmol, 1.0 equiv), iodonium ylides **2** (0.3 mmol, 1.5 equiv), $[Cp^*RhCl_2]_2$ (3.2 mg, 0.005 mmol 2.5 mol %), CsOPiv (46.8 mg, 0.2 mmol, 1.0 equiv), H_2O (18 mg, 1.0 mmol, 5.0 equiv), $AgSbF_6$ (6.86 mg, 0.02 mmol, 0.10 equiv) and HFIP (1.0 ml) was stirred at 70 ^oC for 1.5 h-4.5 h. The reaction mixture was then diluted with DCM (10.0 mL) and washed with H_2O. The aqueous phase was extracted with DCM again. The organic layers were combined, washed with brine and dried over Na_2SO_4. The pure product was purified by flash column chromatography on silica with an appropriate solvent to afford the pure product **3**.

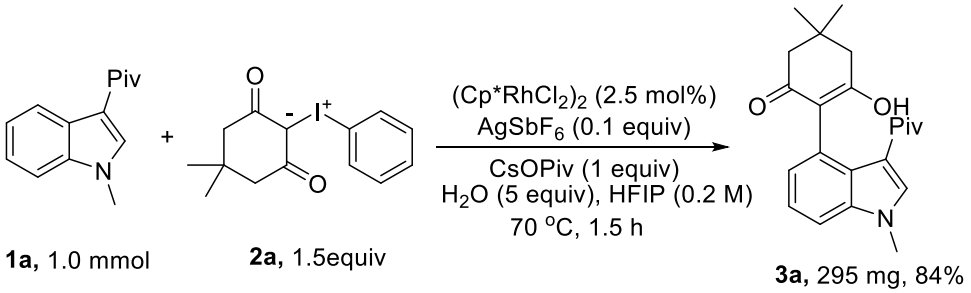
4. Gram scale synthesis and one-pot reaction

Gram scale synthesis



In an oven-dried Schlenk tube under air, a mixture of 2,2-dimethyl-1-(1-methyl-1*H*-indol-3-yl)propan-1-one **1a** (1.07 g, 5.0 mmol, 1.0 equiv), 5,5-dimethyl-2-(phenyl-l3-iodanylidene)cyclohexane-1,3-dione **2a** (2.57 g, 7.5 mmol, 1.5 equiv), $[Cp^*RhCl_2]_2$ (31 mg, 0.05 mmol, 1.0 mol %), CsOPiv (1.17 g, 5.0 mmol, 1.0 equiv), H_2O (450 mg, 25.0 mmol, 5.0 equiv), $AgSbF_6$ (68.6 mg, 0.2 mmol, 0.04 equiv) and HFIP (25 ml) was stirred at 70 °C for 4 h. Upon completion of reaction, the solvent was evaporated under reduced pressure and the crude product was directly purified by a silica gel column chromatography by using EA/PE = 2/1 as the eluent to afford the corresponding product **3a** (1.200 g, 68%).

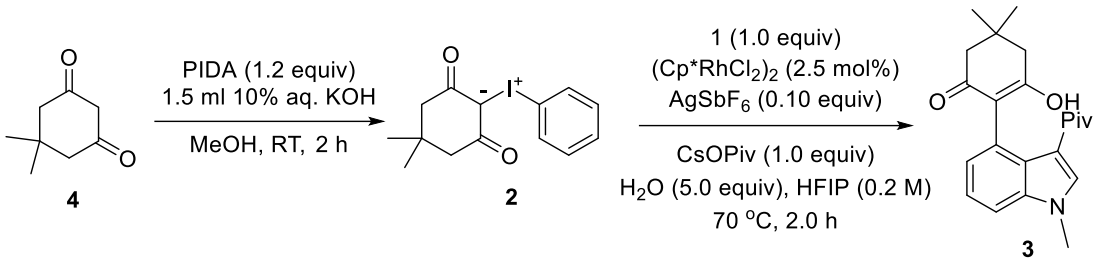
Scale-up Synthesis



In an oven-dried Schlenk tube under air, a mixture of 2,2-dimethyl-1-(1-methyl-1*H*-indol-3-yl)propan-1-one **1a** (215 mg, 1.0 mmol, 1.0 equiv), 5,5-dimethyl-2-(phenyl-l3-iodanylidene)cyclohexane-1,3-dione **2a** (514 mg, 1.5 mmol, 1.5 equiv), $[Cp^*RhCl_2]_2$ (16 mg, 0.025 mmol, 2.5 mol %), CsOPiv (234 mg, 1.0 mmol, 1.0 equiv), H_2O (90 mg, 5.0 mmol, 5.0 equiv), $AgSbF_6$ (34.3 mg, 0.1 mmol, 0.10 equiv) and HFIP (5 ml) was stirred at 70 °C for 1.5 h. Upon completion of reaction, the solvent was evaporated under reduced pressure

and the crude product was directly purified by a silica gel column chromatography by using EA/PE = 2/1 as the eluent to afford the corresponding product **3a** (295 mg, 84%).

One-pot reaction

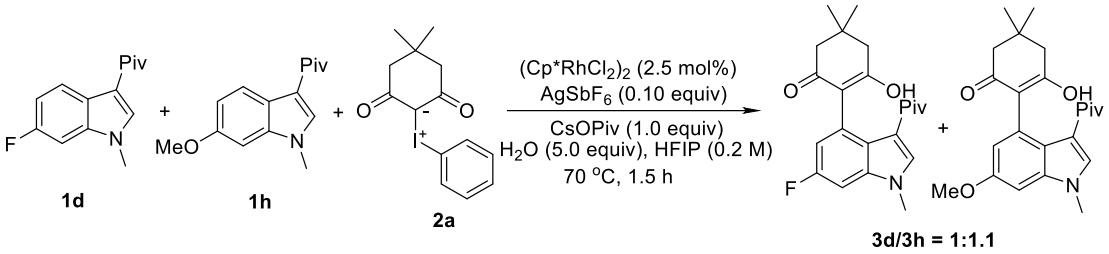


4 **2** **3**

In a 10 mL oven dried reaction tube with a magnetic stir bar, 5,5-dimethylcyclohexane-1,3-dione **4** (105 mg, 0.75 mmol, 1.5 equiv) and MeOH (3 mL) was subjected and kept the solution at RT. Then, 1.5 mL of 10% aq. KOH solution was added to the reaction mixture at RT. The tube was capped with septa. Further, iodoxybenzene diacetate (289 mg, 0.90 mmol, 1.2 equiv) was dissolved in 4 mL MeOH and slowly added to the above reaction mixture via syringe. The resulting mixture was stirred at room temperature for the period of 2 h and evaporate the solvent under reduced pressure After that, 2,2-dimethyl-1-(1-methyl-1*H*-indol-3-yl)propan-1-one **1** (107.5 mg, 0.50 mmol, 1.0 equiv), $[Cp^*RhCl_2]_2$ (8.0 mg, 0.0125 mmol, 2.5 mol %), CsOPiv (117 mg, 0.50 mmol, 1.0 equiv), H_2O (45 mg, 2.5 mmol, 5.0 equiv), $AgSbF_6$ (17.1 mg, 0.05 mmol, 0.10 equiv) and HFIP (2.5 ml) was added to the reaction mixture at 70 ℃. The reaction continued for another 20 minutes and the reaction was monitored by TLC. Upon completion of reaction, the solvent was evaporated under reduced pressure and the crude product was directly purified by a silica gel column chromatography by using EA/PE = 3/1 as the eluent to afford the corresponding product **3**. (160 mg, 90%)

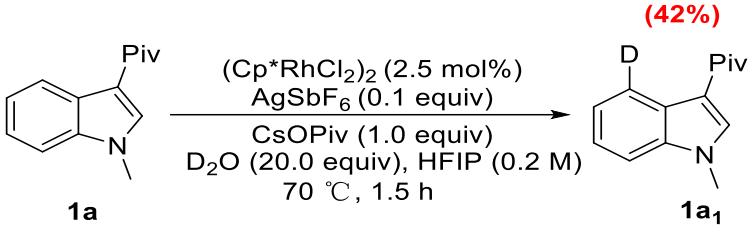
5. Mechanistic experiments

Competitive reaction between indoles

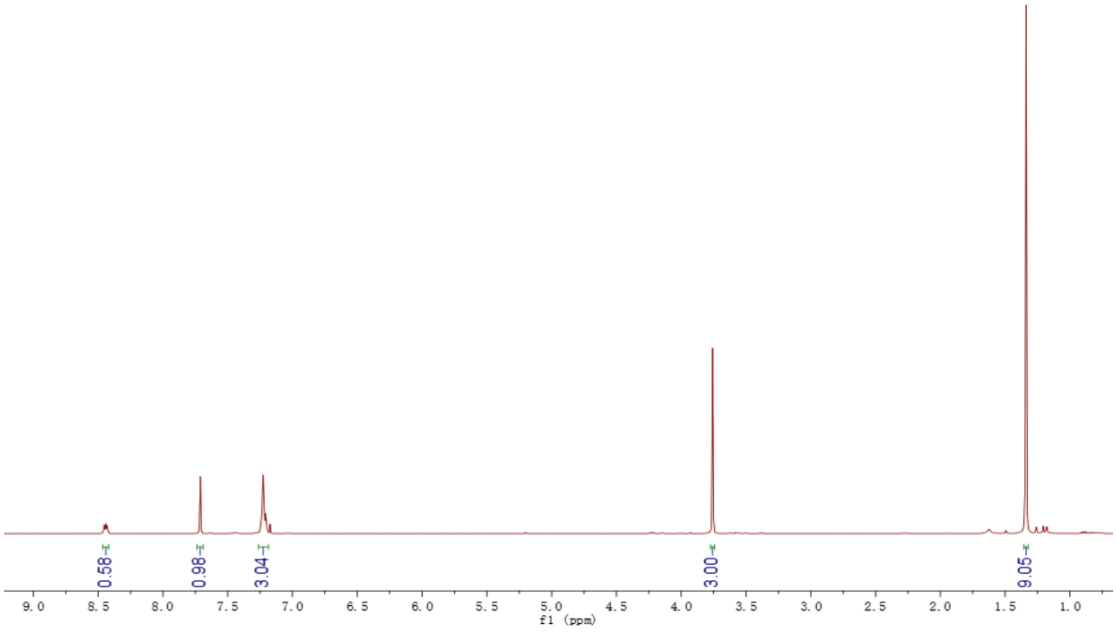


In a 10 mL oven dried reaction tube with a magnetic stir bar was charged with **1d** (23.3 mg, 0.1 mmol, 1.0 equiv), **1h** (24.5 mg, 0.1 mmol, 1.0 equiv), 5,5-dimethyl-2-(phenyl-l3-iodanylidene)cyclohexane-1,3-dione **2a** (0.30 mmol, 1.5 equiv), $[Cp^*RhCl_2]_2$ (3.2 mg, 0.005 mmol, 2.5 mol%), CsOPiv (46.8 mg, 0.20 mmol, 1.0 equiv), H_2O (18 mg, 1.0 mmol, 5.0 equiv), $AgSbF_6$ (6.86 mg, 0.02 mmol, 0.10 equiv) and HFIP (1 ml) was added. Then, the tube was capped with septa and the resulting mixture was stirred at 70℃ for 1.5 h. The solvent was evaporated under reduced pressure, and **3d** and **3h** were obtained directly by silica gel column chromatography. The mass of **3d** and **3h** is 26 mg and 30 mg respectively.

Mechanistic Studies

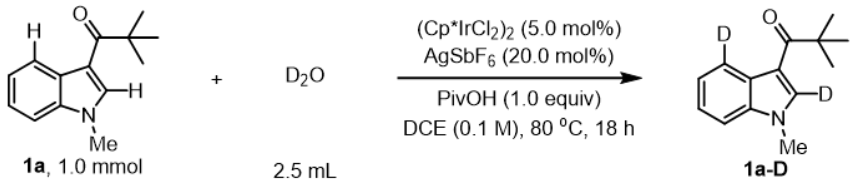


In an oven-dried Schlenk tube under air, a mixture of 2,2-dimethyl-1-(1-methyl-1*H*-indol-3-yl)propan-1-one **1a** (21.5 mg, 0.1 mmol, 1.0 equiv), $[Cp^*RhCl_2]_2$ (1.6 mg, 0.0025 mmol, 2.5 mol %), CsOPiv (23.4 mg, 0.1 mmol, 1.0 equiv), H_2O (9.0 mg, 0.5 mmol, 5.0 equiv), $AgSbF_6$ (3.43 mg, 0.01 mmol, 0.10 equiv) and HFIP (0.5 ml) was stirred at 70 °C for 1.5 h. Upon completion of reaction, the solvent was evaporated under reduced pressure and the crude product was directly purified by a silica gel column chromatography by using EA/PE = 1/8 as the eluent to afford the corresponding product **$1a_1$** (18 mg, 83%).

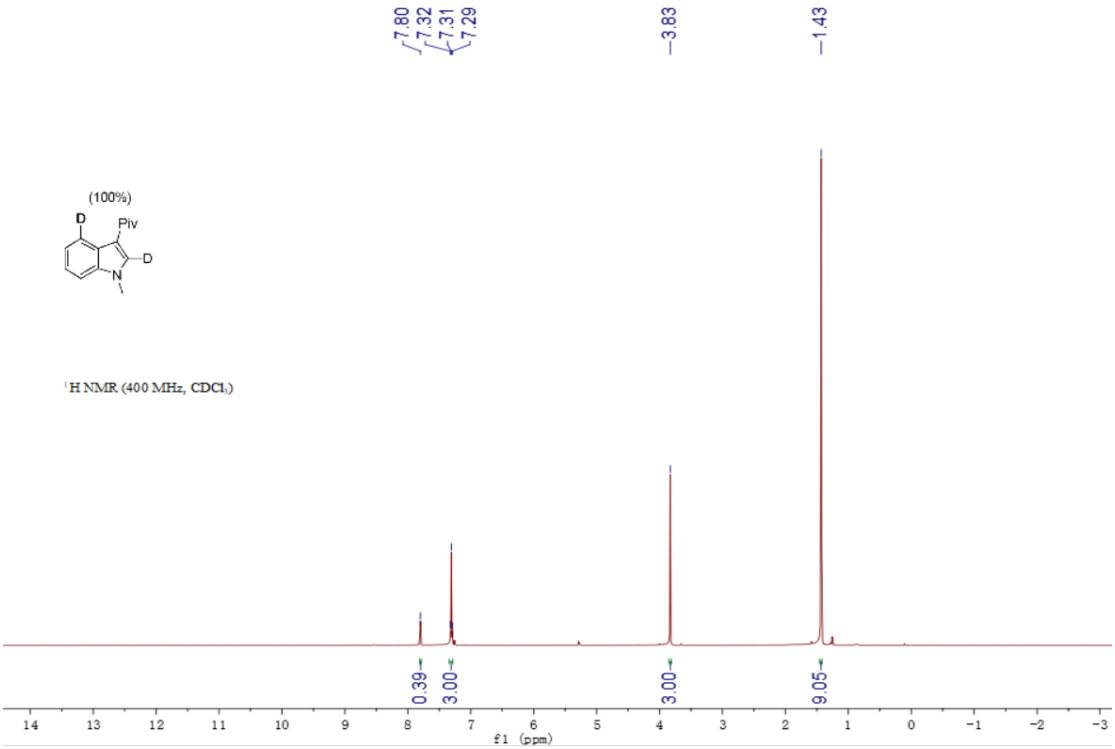


Kinetic isotope effect experiment

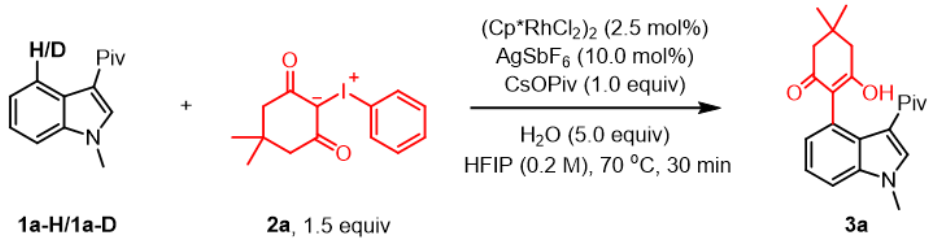
Synthesis of [D_2]-1a



Under N_2 atmosphere, a 15 mL Schlenk tube was charged with 2,2-dimethyl-1-(1-methyl-1*H*-indol-3-yl)propan-1-one **1a** (215.0 mg, 1.0 mmol), $(Cp^*IrCl_2)_2$ (40.0 mg, 5.0 mol%), $AgSbF_6$ (68.5 mg, 20.0 mol%), PivOH (20.4 mg, 1.0 equiv), D_2O (2.5 mL), and DCE (12.5 mL). Then the tube was sealed and the mixture was stirred at 0 °C for 18 h. Subsequently, the reaction solution was cooled to room temperature, diluted with 5 ml CH_2Cl_2, filtered through a celite pad and washed with 30 ml CH_2Cl_2, The filtrate was concentrated under reduced pressure and the residue was purified by flash column chromatography on silica gel (petroleum ether/ethyl acetate = 8:1) to provide the product **1a-D** as a white solid (210 mg, 97%).



Procedure for kinetic isotopic effect experiments

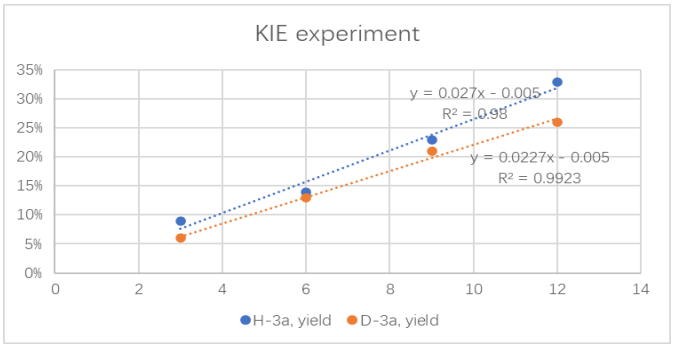


1a-H/1a-D **2a**, 1.5 equiv **3a**

To a Schlenk tube, 2,2-dimethyl-1-(1-methyl-1*H*-indol-3-yl)propan-1-one **1a** (0.3 mmol, 1.0 equiv), **2a** (0.45 mmol, 1.5 equiv), 1-iodo-4-methoxybenzene (0.5 equiv), $(Cp^*RhCl_2)_2$ (4.8 mg, 0.0075 mmol, 2.5 mmol%), $AgSbF_6$ (10.2 mg, 0.03 mmol, 10.0 mmol%), CsOPiv (70.1mg, 0.3mmol, 1.0 equiv), and HFIP (1.5 mL) were added. The resulting mixture was stirred at 70 °C. An aliquot (50 μL) was taken after 3, 6, 9 and 12 minutes respectively. The yield of product **3a** was determined by NMR using 1-iodo-4-methoxybenzene as the internal standard.

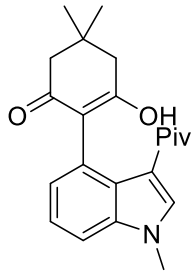
To another Schlenk tube, 2,2-dimethyl-1-(1-methyl-1*H*-indol-3-yl-2,4-d_2)propan-1-one **1a-D** (0.3 mmol, 1.0 equiv), **2a** (0.45 mmol, 1.5 equiv), 1-iodo-4-methoxybenzene (0.5 equiv), $(Cp^*RhCl_2)_2$ (4.8 mg, 0.0075 mmol, 2.5 mmol%), $AgSbF_6$ (10.2 mg, 0.03 mmol, 10.0 mmol%), CsOPiv (70.1mg, 0.3mmol, 1.0 equiv), and HFIP (1.5 mL) were added. The resulting mixture was stirred at 40 °C. An aliquot (50 μL) was taken after 3, 6, 9 and 12 minutes respectively. The yield

of product **3a-D** was determined by NMR using 1-iodo-4-methoxybenzene as the internal standard. The k_H/k_D value was determined to be 0.0270/0.0227 = **1.2.**



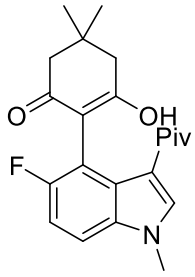
6. NMR data for New Compounds

3-hydroxy-5,5-dimethyl-2-(1-methyl-3-pivaloyl-1*H*-indol-4-yl)cyclohex-2-en-1-one (3a)



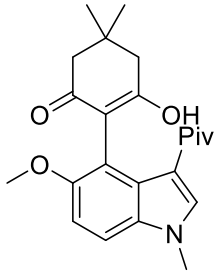
Following the general procedure A, the product **3a** was obtained in 99% yield (70 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 1:3 v/v). RF (Petroleum ether/EtOAc 1:3): 0.26. ^{1}H NMR (400 MHz, DMSO) δ 9.85 (s, 1H), 7.97 (s, 1H), 7.32 (d, *J* = 8.1 Hz, 1H), 7.15 (t, *J* = 7.7 Hz, 1H), 6.79 (d, *J* = 7.1 Hz, 1H), 3.81 (s, 3H), 2.46 (d, *J* = 21.1 Hz, 1H), 2.31 (d, *J* = 19.0 Hz, 2H), 2.04 (d, *J* = 15.0 Hz, 1H), 1.23 (s, 9H), 1.14 (s, 3H), 1.06 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.73, 195.57, 167.18, 136.92, 132.30, 128.02, 126.19, 125.03, 121.57, 116.33, 115.11, 108.26, 50.63, 43.44, 32.89, 31.37, 30.13, 28.73, 27.16. ESI-MS: calculated $C_{20}H_{23}NO_3$ $[M+H]^+$ 326.1756; Found 326.1759.

2-(5-fluoro-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3b)



Following the general procedure A, the product **3b** was obtained in 88% yield (65 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.25. ^{1}H NMR (400 MHz, DMSO) δ 10.08 (s, 1H), 8.02 (s, 1H), 7.36 (dd, *J* = 8.8, 4.3 Hz, 1H), 7.01 (s, 1H), 3.81 (s, 3H), 2.42 (s, 1H), 2.32 (s, 2H), 2.07 (s, 1H), 1.22 (s, 9H), 1.13 (s, 3H), 1.07 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.49, 194.90, 168.63, 155.87 (d, *J* = 232.1 Hz), 133.58, 133.29, 126.98 (d, *J* = 5.9 Hz), 115.23 (d, *J* = 4.6 Hz), 114.13 (d, *J* = 20.6 Hz), 110.25 (d, *J* = 28.4 Hz), 109.61, 109.52, 50.45, 43.51, 43.09, 33.05, 31.52, 30.21, 28.57, 26.70. ^{19}F NMR (376 MHz, DMSO) δ -121.91. ESI-MS: calculated $C_{22}H_{26}FNO_3$ $[M+H]^+$ 372.1975; Found 372.1980.

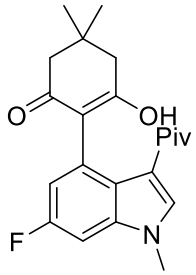
3-hydroxy-2-(5-methoxy-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-5,5-dimethylcyclohex-2-en-1-one (3c)



Following the general procedure A, the product **3c** was obtained in 78% yield (60 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1):

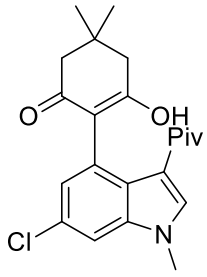
0.25. ^{1}H NMR (400 MHz, DMSO) δ 9.53 (s, 1H), 7.89 (s, 1H), 7.30 (d, *J* = 8.8 Hz, 1H), 6.98 (d, *J* = 8.8 Hz, 1H), 3.77 (s, 3H), 3.61 (s, 3H), 2.37 (s, 1H), 2.34 (s, 1H), 2.19 (s, 1H), 2.05 (s, 1H), 1.21 (s, 9H), 1.11 (s, 6H). ^{13}C NMR (101 MHz, DMSO) δ 201.83, 195.41, 167.33, 152.89, 132.80, 132.59, 127.42, 116.69, 114.64, 111.93, 110.20, 108.96, 57.84, 50.78, 43.65, 43.28, 32.93, 31.70, 30.55, 28.67, 26.53. ESI-MS: calculated $C_{23}H_{29}NO_4$ $[M+H]^+$ 384.2175; Found 384.2177.

2-(6-fluoro-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3d)



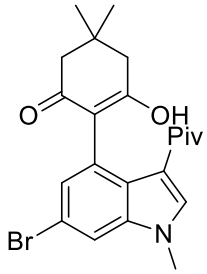
Following the general procedure A, the product **3d** was obtained in 74% yield (53 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.24. ^{1}H NMR (400 MHz, DMSO) δ 10.10 (s, 1H), 7.99 (s, 1H), 7.21 (dd, *J* = 9.5, 2.2 Hz, 1H), 6.62 (dd, *J* = 10.8, 2.0 Hz, 1H), 3.78 (s, 3H), 2.43 (s, 1H), 2.33 (s, 2H), 2.08 (s, 1H), 1.23 (s, 9H), 1.15 (s, 3H), 1.06 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.62 (s), 195.21 (s), 167.81 (s), 158.63 (d, *J* = 235.3 Hz), 136.97 (d, *J* = 13.0 Hz), 132.86 (d, *J* = 2.6 Hz), 129.66 (d, *J* = 10.3 Hz), 122.80 (s), 115.41 (s), 115.35 (s), 112.68 (d, *J* = 23.2 Hz), 94.77 (d, *J* = 25.7 Hz), 50.53 (s), 43.43 (s), 43.12 (s), 32.99 (s), 31.34 (s), 29.99 (s), 28.64 (s), 27.19 (s). ^{19}F NMR (376 MHz, DMSO) δ -122.07 (s). ESI-MS: calculated $C_{22}H_{26}FNO_3$ $[M+H]^+$ 372.1975; Found 372.1977.

2-(6-chloro-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3e)



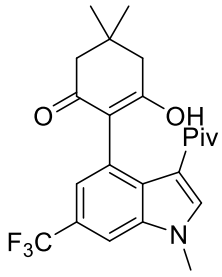
Following the general procedure A, the product **3e** was obtained in 82% yield (64 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.23. ^{1}H NMR (400 MHz, DMSO) δ 10.12 (s, 1H), 8.02 (s, 1H), 7.47 (d, *J* = 1.8 Hz, 1H), 6.77 (d, *J* = 1.8 Hz, 1H), 3.81 (s, 3H), 2.35 (s, 3H), 2.10 (s, 1H), 1.22 (s, 9H), 1.14 (s, 3H), 1.05 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.54, 137.38, 133.13, 129.66, 126.15, 124.98, 124.62, 115.23, 115.17, 108.16, 43.41, 32.99, 31.32, 29.95, 28.54, 27.14. ESI-MS: calculated $C_{22}H_{26}ClNO_3$ $[M+H]^+$ 388.1679; Found 388.1681.

2-(6-bromo-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3f)



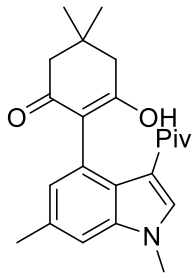
Following the general procedure A, the product **3f** was obtained in 65% yield (56 mg, 0.20 mmol) as a red solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.23. ^{1}H NMR (400 MHz, DMSO) δ 10.13 (s, 1H), 8.01 (s, 1H), 7.60 (s, 1H), 6.89 (s, 1H), 3.81 (s, 3H), 2.35 (s, 2H), 2.21 (s, 1H), 1.98 (s, 1H), 1.22 (s, 9H), 1.14 (s, 3H), 1.05 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.54, 137.74, 133.03, 130.01, 127.16, 125.30, 115.23, 115.13, 114.24, 111.06, 43.42, 33.00, 31.32, 29.95, 28.53, 27.15. ESI-MS: calculated $C_{22}H_{26}BrNO_3$ $[M+H]^+$ 432.1174; Found 432.1172.

3-hydroxy-5,5-dimethyl-2-(1-methyl-3-pivaloyl-6-(trifluoromethyl)-1*H*-indol-4-yl)cyclohex-2-en-1-one (3g)



Following the general procedure A, the product **3g** was obtained in 59% yield (50 mg, 0.20 mmol) as a red solid after column chromatography (eluent = CH_2Cl_2 ether/MeOH 40/1 v/v). RF (CH_2Cl_2 ether/MeOH 40/1): 0.24. ^{1}H NMR (400 MHz, DMSO) δ 10.25 (s, 1H), 8.23 (s, 1H), 7.76 (s, 1H), 7.05 (s, 1H), 3.92 (s, 4H), 2.38 (s, 2H), 2.25 (s, 2H), 1.25 (s, 11H), 1.17 (s, 4H), 1.08 (s, 4H). ^{13}C NMR (101 MHz, DMSO) δ 202.03, 136.45, 135.29, 129.39, 129.06, 127.14, 124.44, 122.88, 122.57, 122.26, 121.13, 115.70, 115.54, 106.26, 43.83, 33.49, 31.72, 30.26, 28.87, 27.65. ^{19}F NMR (376 MHz, DMSO) δ -58.79. ESI-MS: calculated $C_{23}H_{26}F_3NO_3$ $[M+Na]^+$ 444.1762; Found 444.1765.

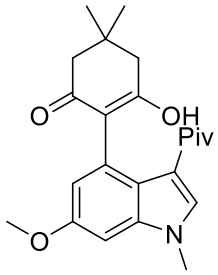
2-(1,6-dimethyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3h)



Following the general procedure A, the product **3h** was obtained in 84% yield (62 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 1:1 v/v). RF (Petroleum ether/EtOAc 1:1): 0.25. ^{1}H NMR (400 MHz, DMSO) δ 9.90 (s, 1H), 7.88 (s, 1H), 7.11 (s, 1H), 6.62 (s, 1H), 3.76 (s, 3H),2.46 (s, 1H), 2.38 (s, 3H), 2.22 (s, 2H), 2.05 (s, 1H), 1.22 (s, 9H), 1.14 (s, 3H), 1.06 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.87, 195.98, 167.40, 137.42, 132.00, 130.80, 127.82, 126.71, 124.28, 116.48, 115.08, 108.36, 50.74, 43.56, 43.40, 32.94, 31.50,

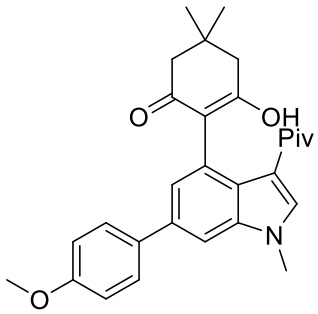
30.28, 28.86, 27.25, 21.48. ESI-MS: calculated $C_{23}H_{29}NO_3$ $[M+H]^+$ 368.2226; Found 368.2229.

3-hydroxy-2-(6-methoxy-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-5,5-dimethylcyclohex-2-en-1-one (3i)



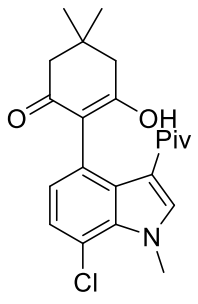
Following the general procedure A, the product **3i** was obtained in 84% yield (64 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 1:1 v/v). RF (Petroleum ether/EtOAc 1:1): 0.26. ^{1}H NMR (400 MHz, DMSO) δ 9.87 (s, 1H), 7.84 (s, 1H), 6.87 (d, *J* = 2.1 Hz, 1H), 6.40 (d, *J* = 2.0 Hz, 1H), 3.78 (s, 3H), 3.76 (s, 3H), 2.42 (s, 1H), 2.32 (s, 1H), 2.28 (s, 1H), 2.04 (s, 1H), 1.21 (s, 9H), 1.13 (s, 3H), 1.04 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.66, 195.49, 167.28, 155.58, 137.66, 131.33, 128.84, 120.43, 116.08, 115.16, 114.60, 91.83, 55.45, 50.62, 43.42, 32.92, 31.35, 30.12, 28.73, 27.16. ESI-MS: calculated $C_{23}H_{29}NO_4$ $[M+H]^+$ 384.2175; Found 384.2173.

3-hydroxy-2-(6-(4-methoxyphenyl)-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-5,5-dimethylcyclohex-2-en-1-one (3j)



Following the general procedure A, the product **3j** was obtained in 78% yield (71 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.22. ^{1}H NMR (400 MHz, DMSO) δ 9.90 (s, 1H), 8.00 (s, 1H), 7.63 (s, 1H), 7.61 (s, 1H), 7.55 (d, *J* = 1.1 Hz, 1H), 7.04 (d, *J* = 1.2 Hz, 1H), 7.03 (s, 1H), 7.01 (s, 1H), 3.87 (s, 3H), 3.79 (s, 3H), 2.46 (s, 1H), 2.37 (s, 2H), 2.09 (s, 1H), 1.25 (s, 9H), 1.16 (s, 3H), 1.09 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.59, 195.53, 167.33, 158.49, 137.67, 133.73, 133.67, 132.76, 128.21, 127.91, 125.18, 123.89, 116.28, 115.01, 114.35, 105.85, 99.62, 55.25, 50.61, 43.40, 43.18, 32.91, 31.34, 30.06, 28.66, 27.26. ESI-MS: calculated $C_{29}H_{33}NO_4$ $[M+H]^+$ 460.2488; Found 460.2491.

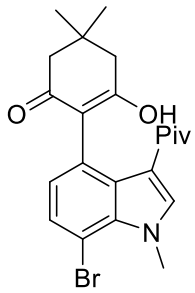
2-(7-chloro-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3k)



Following the general procedure A, the product **3k** was obtained in 97% yield (75 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent =

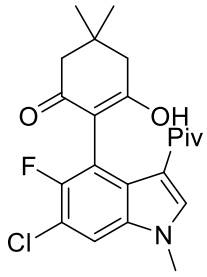
Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.25. ^{1}H NMR (400 MHz, DMSO) δ 10.01 (s, 1H), 7.99 (s, 1H), 7.14 (d, *J* = 7.9 Hz, 1H), 6.71 (d, *J* = 7.9 Hz, 1H), 4.14 (s, 3H), 2.32 (s, 3H), 2.11 (s, 1H), 1.23 (s, 9H), 1.13 (s, 3H), 1.05 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.81, 167.58, 134.70, 131.71, 129.23, 127.39, 125.85, 123.07, 115.37, 115.29, 114.41, 50.56, 43.56, 43.09, 37.06, 31.34, 30.10, 28.51, 26.98. ESI-MS: calculated $C_{22}H_{26}ClNO_3$ $[M+H]^+$ 388.1679; Found 388.1675.

2-(7-bromo-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3l)



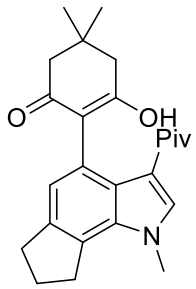
Following the general procedure A, the product **3l** was obtained in 74% yield (64 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.23. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (s, 1H), 7.38 (d, *J* = 7.8 Hz, 1H), 6.82 (s, 1H), 6.79 (d, *J* = 7.8 Hz, 1H), 2.74 (d, *J* = 17.5 Hz, 1H), 2.39 (dd, *J* = 29.1, 16.5 Hz, 2H), 2.17 (d, *J* = 15.3 Hz, 1H), 1.29 (s, 11H), 1.19 (s, 3H), 1.13 (s, 3H).^{13}C NMR (101 MHz, $CDCl_3$) δ 203.50, 196.32, 167.93, 134.42, 133.88, 129.39, 128.30, 126.01, 124.72, 116.58, 115.57, 104.43, 50.51, 44.21, 42.12, 38.11, 31.48, 30.65, 28.69, 26.58. ESI-MS: calculated $C_{22}H_{26}BrNO_3$ $[M+Na]^+$ 454.0994; Found 454.0976.

2-(6-chloro-5-fluoro-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3m)



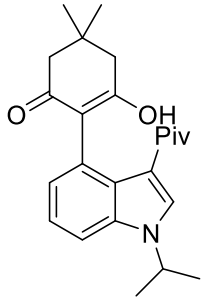
Following the general procedure A, the product **3m** was obtained in 90% yield (68 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.24. ^{1}H NMR (400 MHz, DMSO) δ 10.35 (s, 1H), 8.08 (s, 1H), 7.66 (d, *J* = 6.1 Hz, 1H), 3.81 (s, 3H), 2.44 (s, 1H), 2.34 (s, 2H), 2.10 (s, 1H), 1.22 (s, 9H), 1.14 (s, 3H), 1.08 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.44, 194.71, 169.33, 150.59 (d, *J* = 233.8 Hz), 134.22, 132.84, 125.69 (d, *J* = 4.6 Hz), 115.87 (d, *J* = 20.6 Hz), 115.32 (d, *J* = 4.4 Hz), 114.67 (d, *J* = 23.2 Hz), 110.02, 108.95, 50.36, 43.57, 43.07, 33.19, 31.55, 30.17, 28.46, 26.56. ^{19}F NMR (376 MHz, DMSO) δ -124.07. ESI-MS: calculated $C_{22}H_{25}ClFNO_3$ $[M+H]^+$ 406.1585; Found 406.1589.

3-hydroxy-5,5-dimethyl-2-(1-methyl-3-pivaloyl-1,6,7,8-tetrahydrocyclopenta[g]indol-4-yl)cyclohex-2-en-1-one (3n)+-



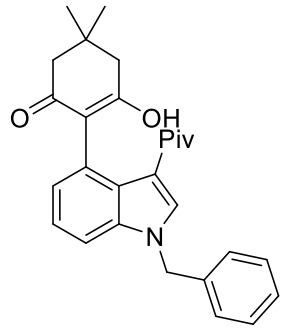
Following the general procedure A, the product **3n** was obtained in 90% yield (71 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.22. ^{1}H NMR (400 MHz, DMSO) δ 9.65 (s, 1H), 7.79 (s, 1H), 6.62 (s, 1H), 3.96 (s, 3H), 2.87 (t, *J* = 7.2 Hz, 2H), 2.40 (s, 4H), 2.29 (s, 1H), 2.13 (s, 1H), 2.10 (dd, *J* = 14.3, 7.1 Hz, 2H), 2.02 (s, 1H), 1.21 (s, 9H), 1.12 (s, 3H), 1.04 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.82, 138.00, 133.89, 132.08, 126.03, 125.37, 123.68, 121.77, 116.56, 115.19, 50.67, 43.45, 43.25, 35.18, 32.21, 31.33, 30.79, 30.27, 28.70, 26.92, 25.23. ESI-MS: calculated $C_{25}H_{31}NO_3$ $[M+H]^+$ 394.2382; Found 394.2384.

3-hydroxy-2-(1-isopropyl-3-pivaloyl-1*H*-indol-4-yl)-5,5-dimethylcyclohex-2-en-1-one (3o)



Following the general procedure A, the product **3o** was obtained in 72% yield (55 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.22. ^{1}H NMR (400 MHz, DMSO) δ 9.81 (s, 1H), 7.90 (s, 1H), 7.43 (d, *J* = 8.2 Hz, 1H), 7.13 (t, *J* = 7.7 Hz, 1H), 6.77 (d, *J* = 7.2 Hz, 1H), 2.38 (s, 3H),2.11 (s, 1H), 1.52 (s, 3H), 1.50 (s, 3H), 1.24 (s, 9H), 1.15 (s, 3H), 1.07 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 202.26, 195.41, 167.19, 135.67, 128.06, 126.78, 126.13, 124.92, 121.41, 116.26, 115.71, 108.44, 50.46, 46.96, 43.42, 42.96, 31.31, 30.13, 28.69, 27.03, 22.32. ESI-MS: calculated $C_{24}H_{31}NO_3$ $[M+H]^+$ 382.2382; Found 382.2383.

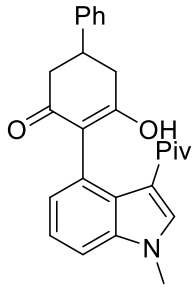
2-(1-benzyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethylcyclohex-2-en-1-one (3p)



Following the general procedure A, the product **3p** was obtained in 82% yield (70 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 1:2 v/v). RF (Petroleum ether/EtOAc 1:3): 0.23. ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.53 (s, 1H), 7.28 – 7.14 (m, 6H), 7.06 (d, *J* = 6.9 Hz, 2H), 6.93 (dd, *J* = 6.3, 1.4 Hz, 1H), 5.25 (s, 2H), 2.65 (d, *J* = 17.6 Hz, 1H), 2.44 (d, *J* = 15.5 Hz, 1H), 2.29 (d, *J* = 17.1 Hz, 1H), 2.13 (d, *J* = 15.5 Hz, 1H), 1.22 (s, 9H), 1.13 (s, 3H),

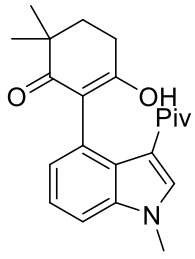
1.08 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 204.14, 196.94, 167.68, 137.26, 136.07, 131.09, 128.99, 128.08, 126.87, 126.80, 125.25, 125.13, 123.41, 117.32, 116.31, 110.44, 44.18, 41.89, 31.52, 30.55, 29.70, 28.70, 26.70. ESI-MS: calculated $C_{28}H_{31}NO_3$ $[M+H]^+$ 430.2382; Found 430.2377.

5-hydroxy-4-(1-methyl-3-pivaloyl-1*H*-indol-4-yl)-1,6-dihydro-[1,1'-biphenyl]-3(2H)-one (3q)



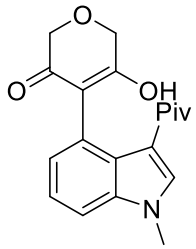
Following the general procedure A, the product **3q** was obtained in 97% yield (78 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 1:3 v/v). RF (Petroleum ether/EtOAc 1:3): 0.26. ^{1}H NMR (400 MHz, DMSO) δ 10.11 (s, 1H), 8.01 (d, *J* = 3.0 Hz, 1H), 7.39 (d, *J* = 8.0 Hz, 3H), 7.37 – 7.32 (m, 2H), 7.27 (dd, *J* = 8.2, 3.6 Hz, 1H), 7.18 (t, *J* = 7.7 Hz, 1H), 6.84 (d, *J* = 7.2 Hz, 1H), 3.83 (s, 3H), 3.67 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.88 (dd, *J* = 16.4, 11.5 Hz, 1H), 2.66 (dd, *J* = 30.7, 12.0 Hz, 2H), 2.37 (dd, *J* = 22.9, 16.7 Hz, 1H), 1.26 (d, *J* = 8.4 Hz, 9H). ^{13}C NMR (101 MHz, DMSO) δ 202.00, 201.77, 194.93, 194.60, 168.67, 168.48, 144.11, 143.93, 136.88, 132.54, 132.38, 128.82, 128.78, 127.92, 127.83, 126.93, 126.80, 126.76, 126.72, 126.06, 124.81, 121.62, 117.23, 116.62, 115.07, 114.95, 108.40, 108.32, 44.21, 43.49, 43.46, 38.33, 38.09, 37.23, 37.14, 32.87, 28.71, 28.63. ESI-MS: calculated $C_{26}H_{27}NO_3$ $[M+H]^+$ 402.2069; Found 402.2068.

3-hydroxy-6,6-dimethyl-2-(1-methyl-3-pivaloyl-1*H*-indol-4-yl)cyclohex-2-en-1-one (3r)



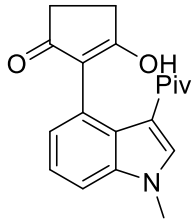
Following the general procedure A, the product **3r** was obtained in 64% yield (48.9 mg, 0.20 mmol) as a red solid after column chromatography (eluent = Petroleum ether/EtOAc 1:3 v/v). RF (Petroleum ether/EtOAc 1:3): 0.25. ^{1}H NMR (400 MHz, DMSO) δ 9.72 (s, 1H), 7.99 (s, 1H), 7.31 (d, *J* = 8.2 Hz, 1H), 7.14 (t, *J* = 7.7 Hz, 1H), 6.71 (d, *J* = 7.2 Hz, 1H), 3.82 (s, 3H), 2.49 (d, *J* = 1.7 Hz, 1H), 2.45 (d, *J* = 6.0 Hz, 1H), 1.97 (d, *J* = 5.9 Hz, 1H), 1.76 (d, *J* = 6.2 Hz, 1H), 1.25 (s, 9H), 1.13 (s, 3H), 1.06 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.00, 200.01, 167.66, 136.87, 132.45, 128.71, 126.24, 125.16, 121.46, 115.34, 114.93, 108.03, 43.41, 34.11, 32.85, 28.71, 28.28, 26.30, 25.21. ESI-MS: calculated $C_{22}H_{27}NO_3$ $[M+H]^+$ 354.2069; Found 354.2071.

5-hydroxy-4-(1-methyl-3-pivaloyl-1*H*-indol-4-yl)-2*H*-pyran-3(6*H*)-one (3s)



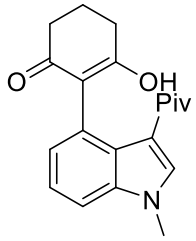
Following the general procedure A, the product **3s** was obtained in 92% yield (60 mg, 0.20 mmol) as a red solid after column chromatography (eluent = CH_2Cl_2 ether/MeOH 100/1 v/v). RF (CH_2Cl_2 ether/MeOH 100/1): 0.25. ^{1}H NMR (400 MHz, DMSO) δ 10.67 (s, 1H), 8.04 (s, 1H), 7.39 (d, *J* = 7.6 Hz, 1H), 7.19 (t, *J* = 7.7 Hz, 1H), 6.86 (d, *J* = 7.2 Hz, 1H), 4.19 (s, 4H), 3.83 (s, 3H), 1.23 (s, 9H).^{13}C NMR (101 MHz, DMSO) δ 201.68, 136.95, 132.86, 124.68, 121.76, 115.22, 114.94, 108.96, 43.43, 32.91, 28.94, 28.69. ESI-MS: calculated $C_{19}H_{21}NO_4$ $[M+H]^+$ 328.1549; Found 328.1543.

3-hydroxy-2-(1-methyl-3-pivaloyl-1*H*-indol-4-yl)cyclopent-2-en-1-one (3t)



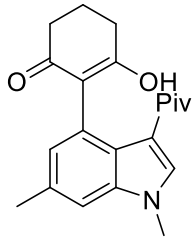
Following the general procedure A, the product **3t** was obtained in 82% yield (55 mg, 0.20 mmol) as a white solid after column chromatography (eluent = CH_2Cl_2 ether/MeOH 50/1 v/v). RF (CH_2Cl_2 ether/MeOH 50/1): 0.26. ^{1}H NMR (400 MHz, DMSO) δ 11.45 (s, 1H), 8.04 (s, 1H), 7.37 (d, *J* = 8.0 Hz, 1H), 7.20 (t, *J* = 7.7 Hz, 1H), 6.98 (d, *J* = 7.2 Hz, 1H), 3.83 (s, 3H), 2.49 (s, 2H), 2.35 (s, 2H) 1.27 (s, 9H). ^{13}C NMR (101 MHz, DMSO) δ 201.50, 136.98, 132.56, 125.28, 124.77, 123.26, 121.72, 117.98, 115.48, 108.56, 55.02, 43.24, 32.87, 28.78. ESI-MS: calculated $C_{19}H_{21}NO_3$ $[M+H]^+$ 312.1600; Found 312.1604.

3-hydroxy-2-(1-methyl-3-pivaloyl-1*H*-indol-4-yl)cyclohex-2-en-1-one (3u)



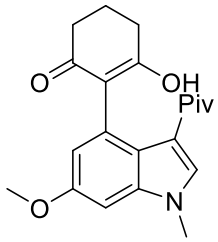
Following the general procedure A, the product **3u** was obtained in 95.3% yield (31 mg, 0.10 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 1:1 v/v). RF (Petroleum ether/EtOAc 1:1): 0.21. ^{1}H NMR (400 MHz, DMSO) δ 9.88 (s, 1H), 7.97 (s, 1H), 7.31 (d, *J* = 7.6 Hz, 1H), 7.15 (t, *J* = 7.7 Hz, 1H), 6.78 (d, *J* = 6.6 Hz, 1H), 3.81 (s, 3H), 2.51 (d, *J* = 9.5 Hz , 2H), 2.25 (d, *J* = 20.0 Hz, 2H), 2.08 (dt, *J* = 12.1, 6.1 Hz, 1H), 1.90 (dt, *J* = 12.6, 6.1 Hz, 1H), 1.24 (s, 9H).^{13}C NMR (101 MHz, DMSO) δ 202.03, 195.98, 169.75, 137.21, 132.63, 128.52, 126.47, 125.21, 121.91, 117.64, 115.41, 108.54, 43.81, 37.14, 33.20, 29.91, 29.02, 20.70. ESI-MS: calculated $C_{20}H_{23}NO_3$ $[M+H]^+$ 326.1756; Found 326.1759.

2-(1,6-dimethyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxycyclohex-2-en-1-one (3v)



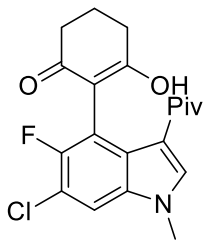
Following the general procedure A, the product **3v** was obtained in 85% yield (57 mg, 0.20 mmol) as a white solid after column chromatography (eluent = Petroleum ether/EtOAc 3:2 v/v). RF (Petroleum ether/EtOAc 3:2): 0.25. ^{1}H NMR (400 MHz, DMSO) δ 9.85 (s, 1H), 7.88 (s, 1H), 7.11 (s, 1H), 6.61 (s, 1H), 3.77 (s, 3H), 2.55 (d, *J* = 11.5 Hz, 1H), 2.44 (d, *J* = 3.8 Hz, 1H), 2.38 (s, 3H), 2.29 (d, *J* = 6.2 Hz, 1H), 2.23 (d, *J* = 7.8 Hz, 1H), 2.07 (dt, *J* = 12.3, 6.2 Hz, 1H), 1.87 (dt, *J* = 12.7, 6.3 Hz, 1H), 1.22 (s, 9H). ^{13}C NMR (101 MHz, DMSO) δ 201.63, 195.76, 169.37, 137.26, 131.85, 130.64, 127.86, 126.48, 124.11, 117.33, 114.92, 108.16, 55.04, 43.45, 36.81, 32.79, 28.68, 21.35, 20.37. ESI-MS: calculated $C_{21}H_{25}NO_3$ $[M+H]^+$ 340.1913; Found 340.1917.

3-hydroxy-2-(6-methoxy-1-methyl-3-pivaloyl-1*H*-indol-4-yl)cyclohex-2-en-1-one (3w)



Following the general procedure A, the product **3w** was obtained in 70% yield (50 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 1:1 v/v). RF (Petroleum ether/EtOAc 1:1): 0.22. ^{1}H NMR (400 MHz, DMSO) δ 9.93 (s, 1H), 7.83 (s, 1H), 6.86 (s, 1H), 6.39 (s, 1H), 3.78 (s, 3H), 3.76 (s, 3H), 2.29 – 2.23 (m, 2H), 2.22 (d, *J* = 12.6 Hz, 2H), 2.04 (d, *J* = 6.0 Hz, 1H), 1.87 (d, *J* = 6.0 Hz, 1H), 1.21 (s, 9H). ^{13}C NMR (101 MHz, DMSO) δ 201.68, 195.63, 169.56, 155.63, 137.61, 131.32, 129.00, 120.36, 117.06, 115.10, 114.39, 91.83, 55.42, 43.46, 36.75, 32.89, 29.52, 28.67, 20.29. ESI-MS: calculated $C_{21}H_{25}NO_4$ $[M+H]^+$ 356.1862; Found 356.1864.

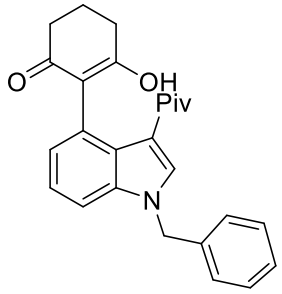
2-(6-chloro-5-fluoro-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxycyclohex-2-en-1-one (3x)



Following the general procedure A, the product **3x** was obtained in 93% yield (70 mg, 0.20 mmol) as a white solid after column chromatography (eluent = CH_2Cl_2 ether/EtOAc 6:1 v/v). RF (CH_2Cl_2 ether/EtOAc 6:1): 0.21. ^{1}H NMR (400 MHz, DMSO) δ 10.40 (s, 1H), 8.07 (s, 1H), 7.66 (d, *J* = 6.0 Hz, 1H), 3.81 (s, 3H), 2.54 (s, 2H), 2.28 (s, 2H), 2.08 (dt, *J* = 12.2, 6.1 Hz, 1H), 1.90 (dt, *J* = 12.4, 6.1 Hz, 1H), 1.21 (s, 9H). ^{13}C NMR (101 MHz, DMSO) δ 201.44, 194.87, 171.49, 150.57 (d, *J* = 234.1 Hz), 134.20, 132.81, 125.57 (d, *J* = 4.7 Hz), 115.95 (d, *J* = 20.9 Hz), 115.32

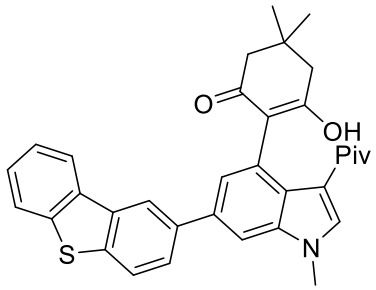
(d, *J* = 4.4 Hz), 114.67 (d, *J* = 23.2 Hz), 110.01, 109.91, 43.58, 36.46, 33.18, 29.38, 28.41, 20.27. ^{19}F NMR (376 MHz, DMSO) δ -124.38. ESI-MS: calculated $C_{20}H_{23}NO_3$ $[M+H]^+$ 326.1756; Found 326.1759.

2-(1-benzyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxycyclohex-2-en-1-one (3y)



Following the general procedure A, the product **3y** was obtained in 60% yield (49 mg, 0.20 mmol) as a gray solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.26. ^{1}H NMR (400 MHz, DMSO) δ 9.94 (s, 1H), 8.20 (s, 1H), 7.30 (t, *J* = 7.5 Hz, 5H), 7.26 (d, *J* = 6.8 Hz, 1H), 7.09 (d, *J* = 7.6 Hz, 1H), 6.75 (d, *J* = 7.2 Hz, 1H), 5.46 (s, 2H), 2.51 (s, 2H) 2.25 (d, *J* = 19.5 Hz, 2H), 2.08 (dt, *J* = 12.1, 6.1 Hz, 1H), 1.88 (dt, *J* = 12.2, 6.0 Hz, 1H), 1.26 (s, 9H). ^{13}C NMR (101 MHz, DMSO) δ 202.13, 195.69, 169.58, 137.77, 136.01, 131.62, 128.70, 128.25, 127.62, 127.32, 126.31, 124.92, 121.63, 117.15, 115.52, 108.80, 49.38, 43.56, 36.77, 29.56, 28.62, 20.32. ESI-MS: calculated $C_{26}H_{27}NO_3$ $[M+H]^+$ 402.2069; Found 402.2074.

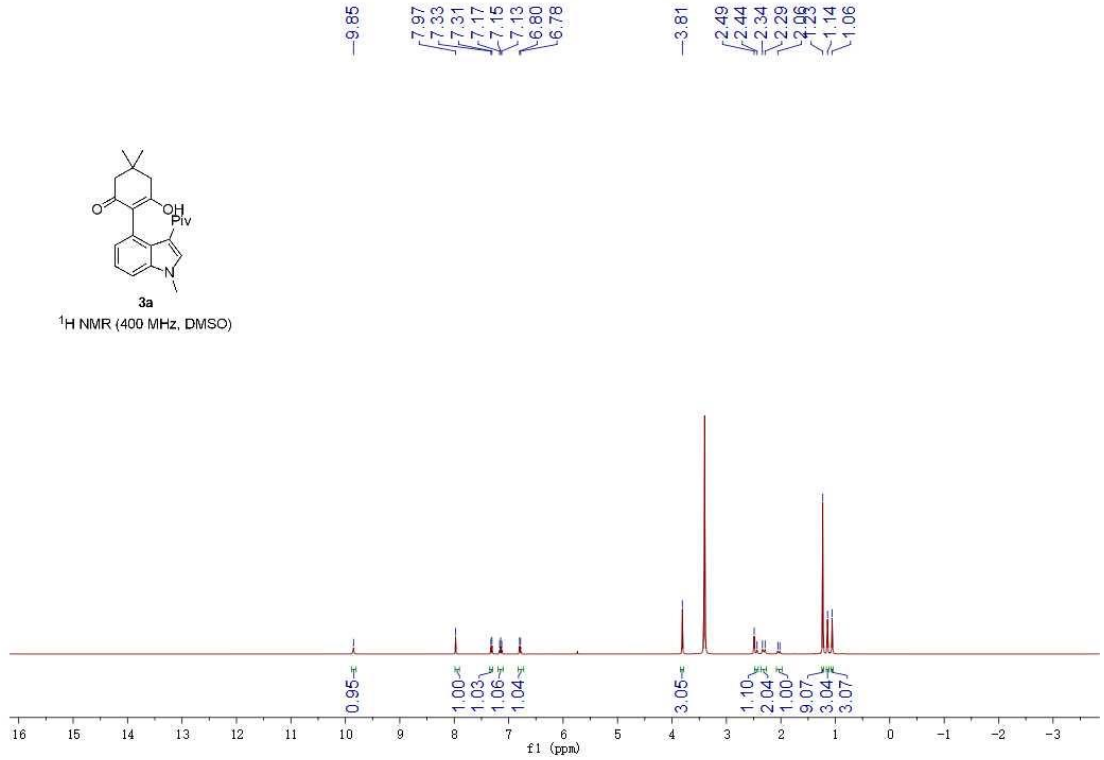
2-(6-(dibenzo[b,d]thiophen-2-yl)-1-methyl-3-pivaloyl-1*H*-indol-4-yl)-3-hydroxy-5,5-dimethyl cyclohex-2-en-1-one (3z)



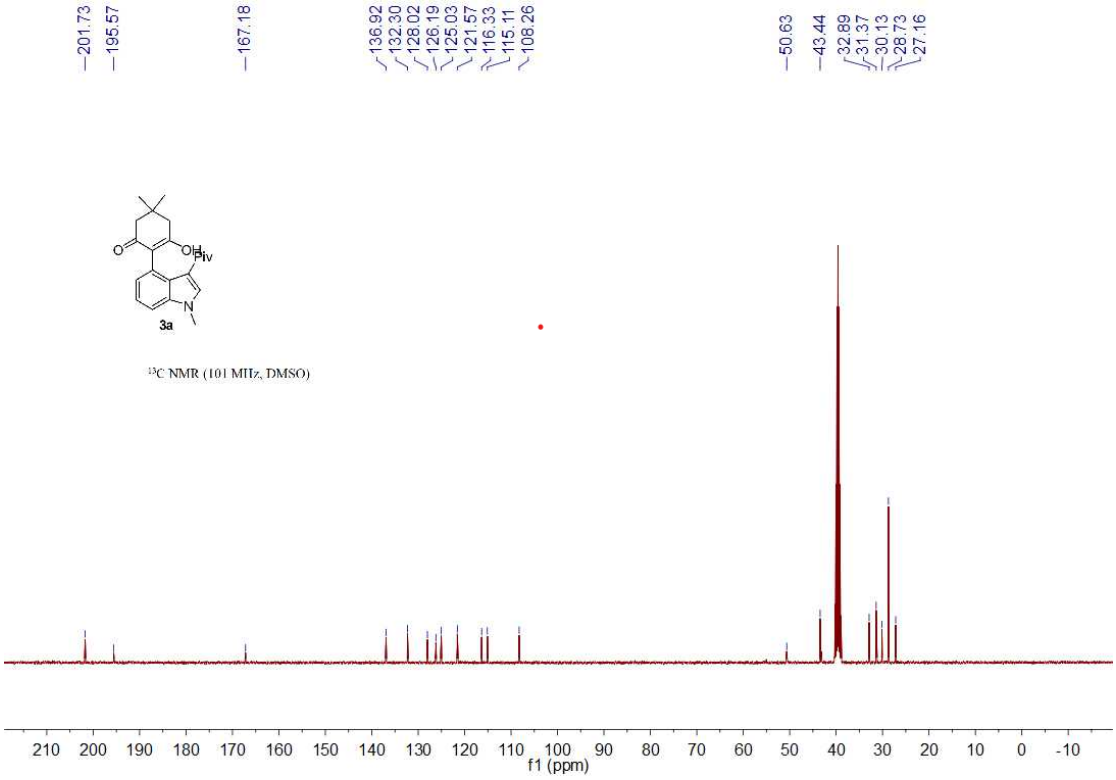
Following the general procedure A, the product **3z** was obtained in 66% yield (70 mg, 0.20 mmol) as a yellow solid after column chromatography (eluent = Petroleum ether/EtOAc 2:1 v/v). RF (Petroleum ether/EtOAc 2:1): 0.23. ^{1}H NMR (400 MHz, DMSO) δ 9.96 (s, 1H), 8.70 (d, *J* = 0.9 Hz, 1H), 8.54 (dd, *J* = 6.0, 3.1 Hz, 1H), 8.09 (d, *J* = 8.4 Hz, 1H), 8.06 (s, 1H), 8.03 (d, *J* = 5.8 Hz, 1H), 7.88 (dd, *J* = 8.4, 1.4 Hz, 1H), 7.84 (d, *J* = 1.2 Hz, 1H), 7.56 – 7.50 (m, 2H), 7.30 (s, 1H), 3.95 (s, 3H), 2.53 (s, 1H), 2.40 (s, 1H), 2.36 (s, 1H), 2.13 (s, 1H), 1.27 (s, 9H), 1.18 (s, 3H), 1.13 (s, 3H). ^{13}C NMR (101 MHz, DMSO) δ 201.65, 195.57, 167.44, 139.14, 138.16, 137.75, 137.05, 135.83, 135.27, 133.55, 133.09, 128.42, 127.26, 126.35, 125.73, 124.74, 124.28, 123.39, 123.20, 122.51, 119.82, 116.27, 115.09, 106.77, 50.64, 43.44, 43.21, 33.02, 31.36, 30.09, 28.67, 27.42. ESI-MS: calculated $C_{34}H_{33}NO_3S$ $[M+H]^+$ 536.2259; Found 536.2255.

7. Copies of product NMR spectra

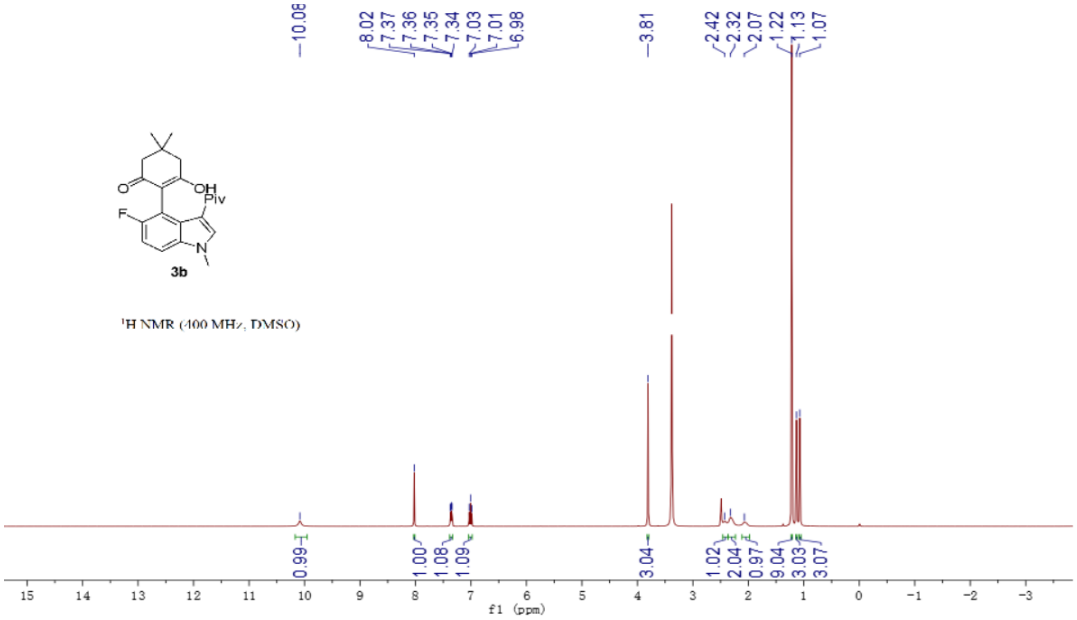
^{1}H NMR (400 MHz, DMSO) Spectra of **3a**



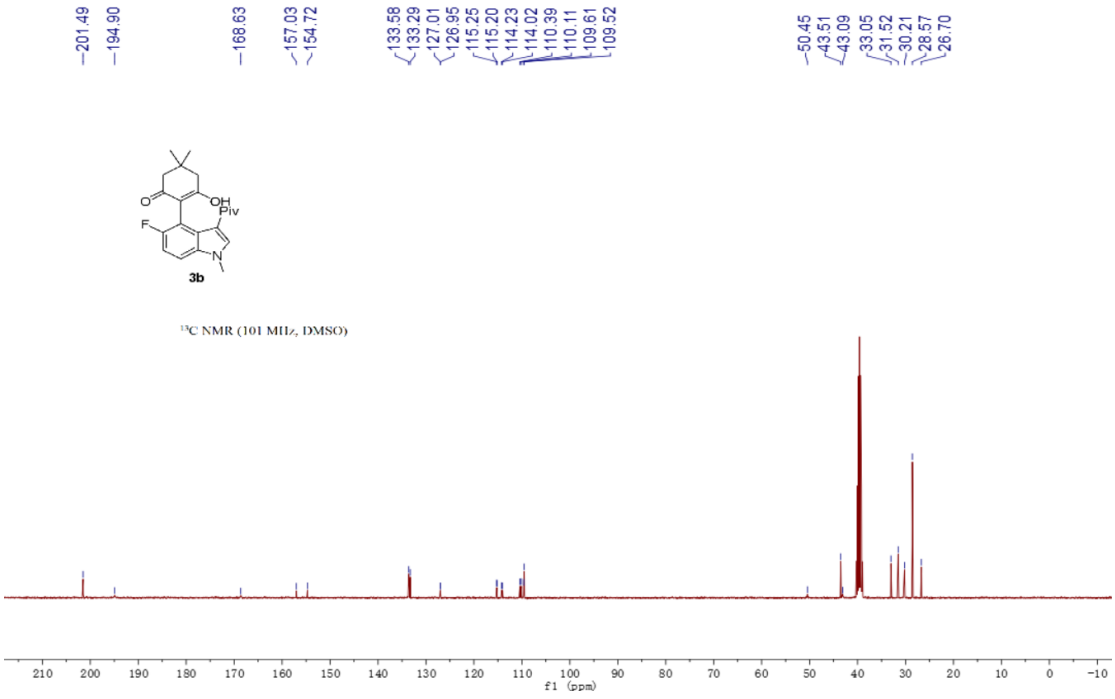
^{13}C NMR (101 MHz, DMSO) Spectra of **3a**



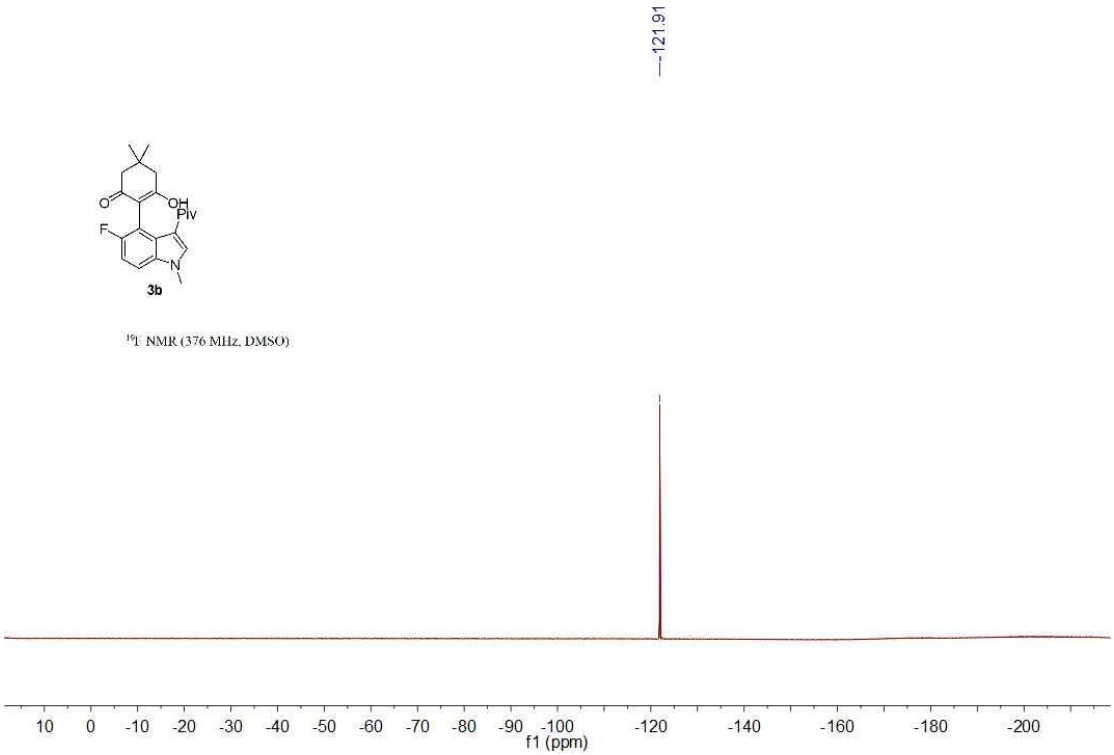
^{1}H NMR (400 MHz, DMSO) Spectra of **3b**



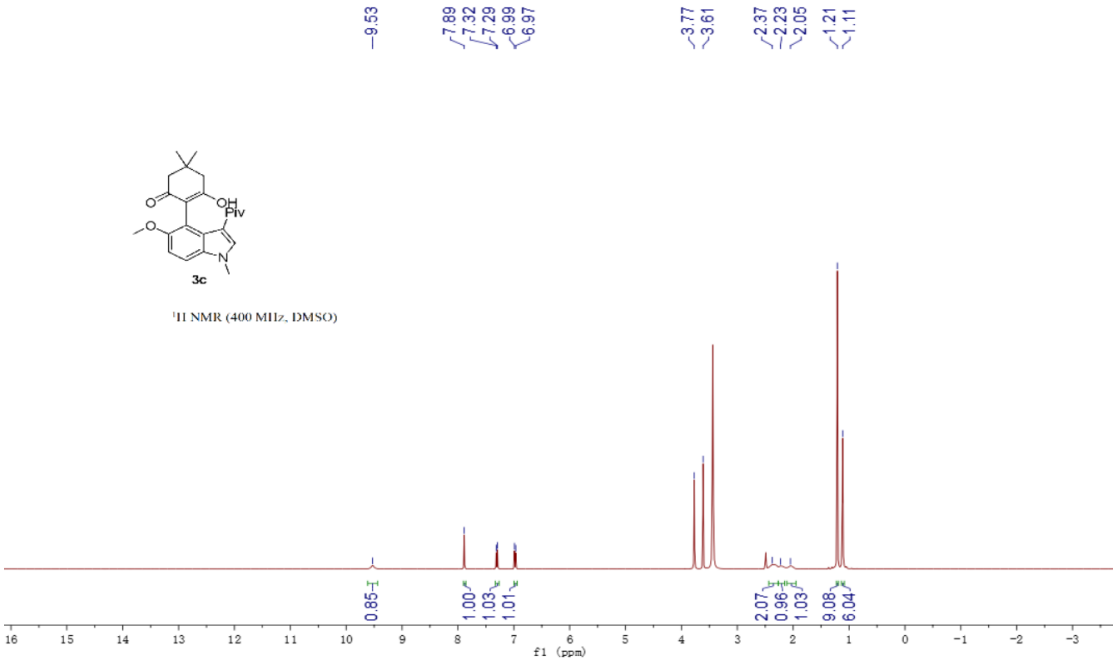
^{13}C NMR (101 MHz, DMSO) Spectra of **3b**



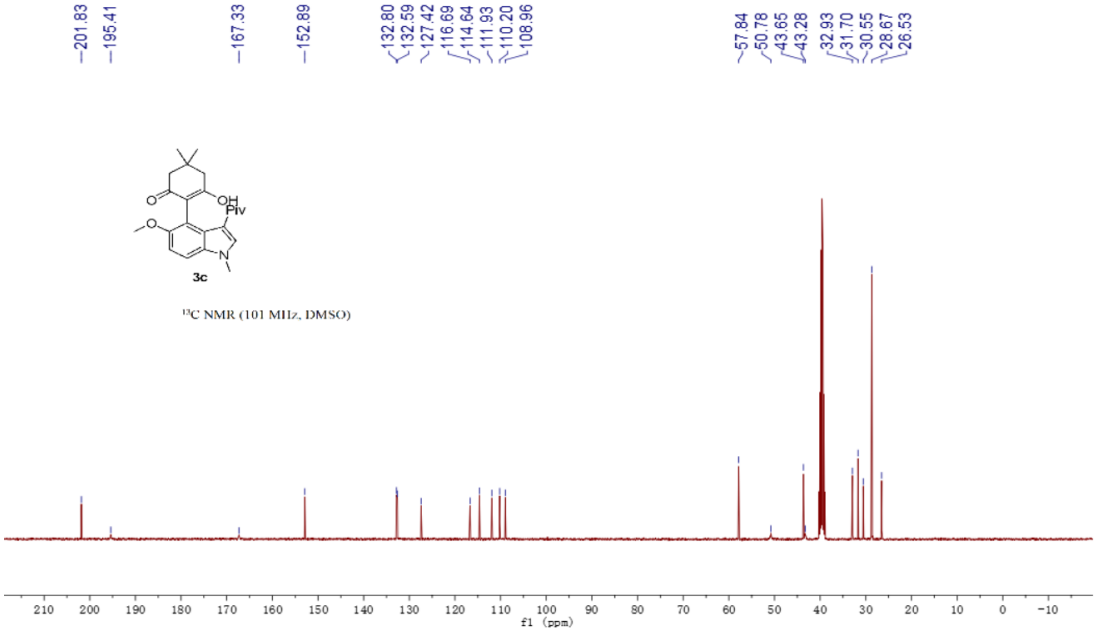
^{19}F NMR (376 MHz, DMSO) Spectra of **3b**



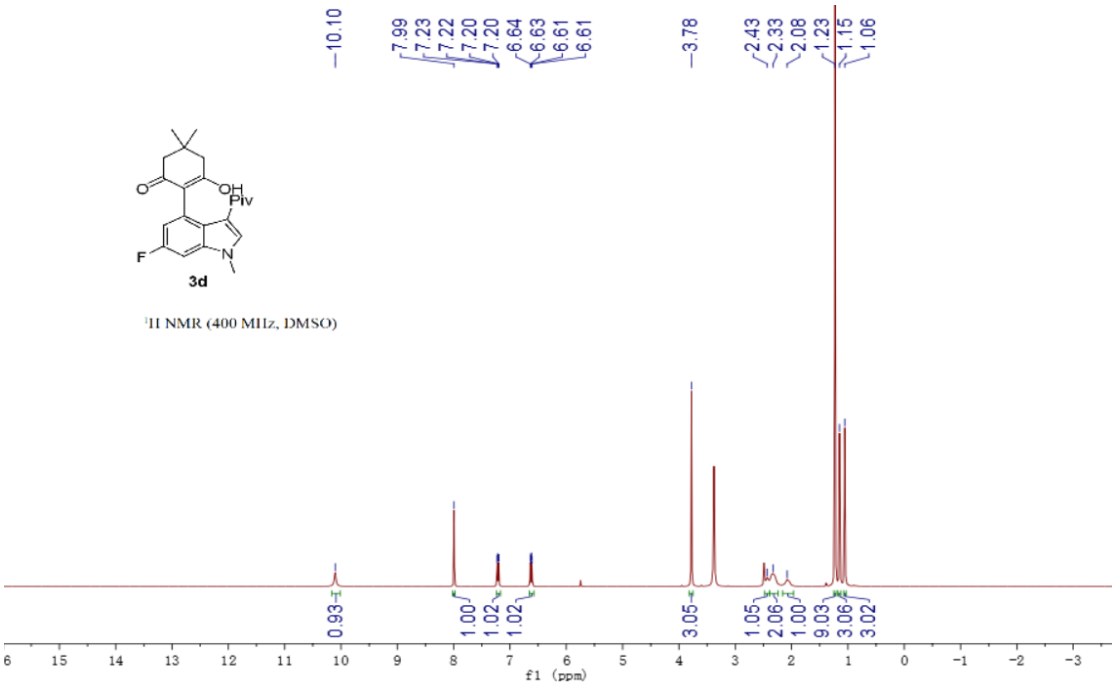
^{1}H NMR (400 MHz, DMSO) Spectra of **3c**



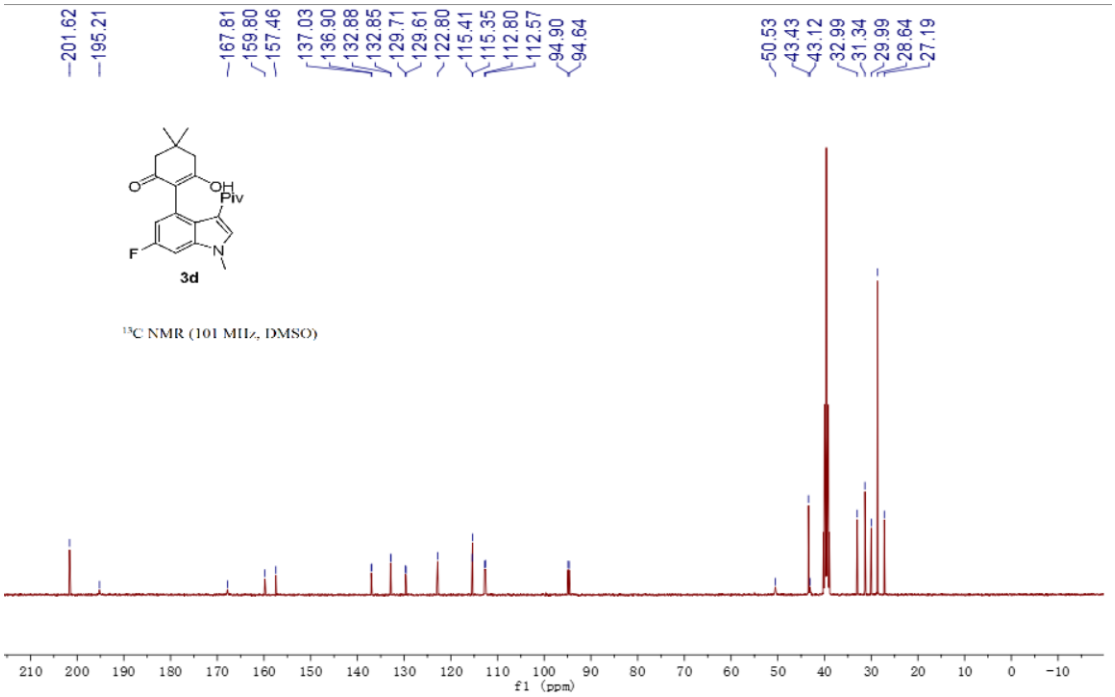
^{13}C NMR (101 MHz, DMSO) Spectra of **3c**



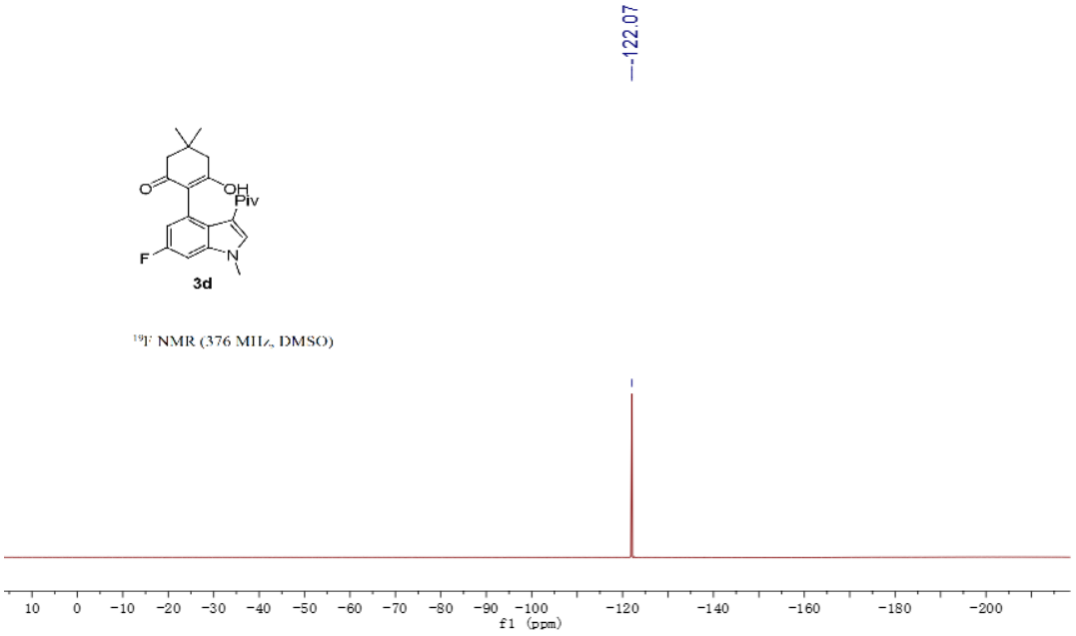
^{1}H NMR (400 MHz, DMSO) Spectra of **3d**



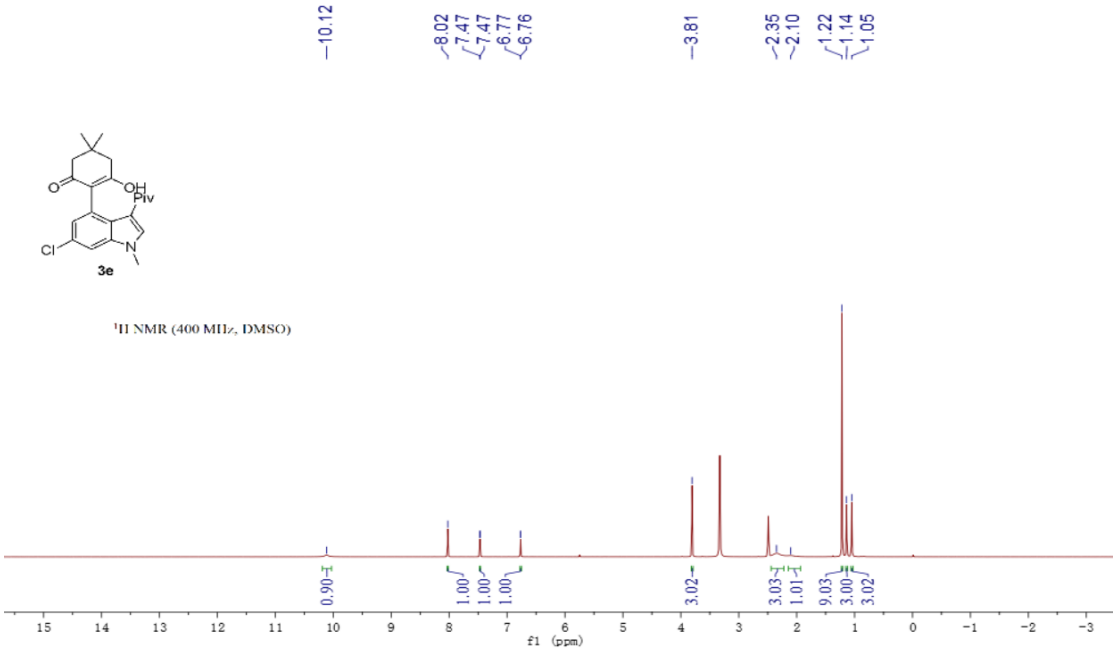
^{13}C NMR (101 MHz, DMSO) Spectra of **3d**



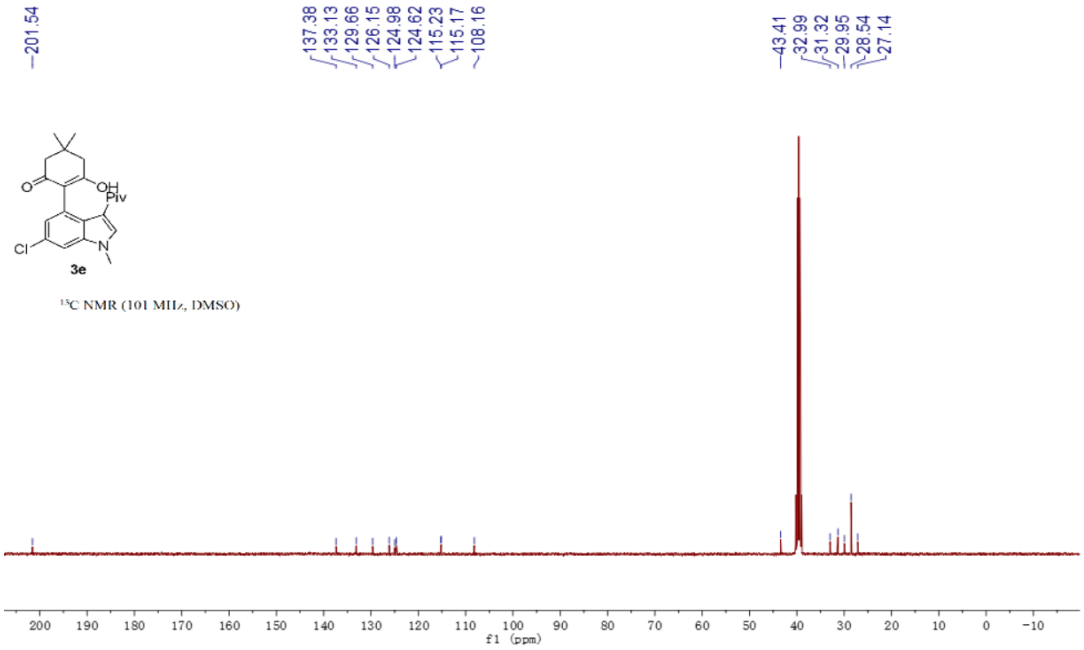
^{19}F NMR (376 MHz, DMSO) Spectra of **3d**



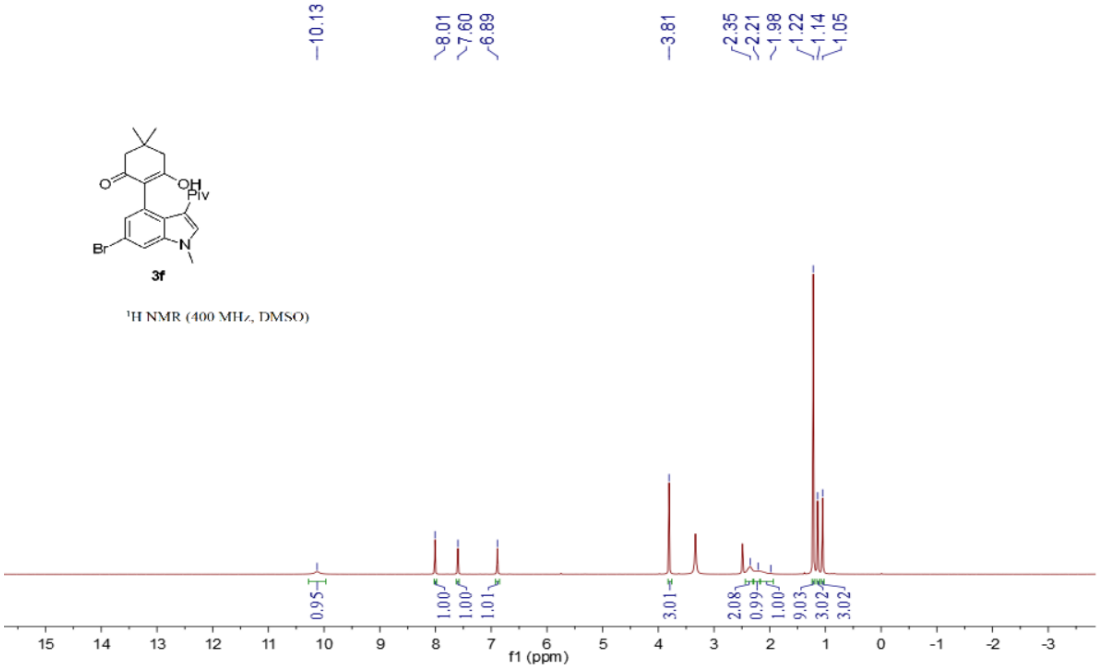
^{1}H NMR (400 MHz, DMSO) Spectra of **3e**



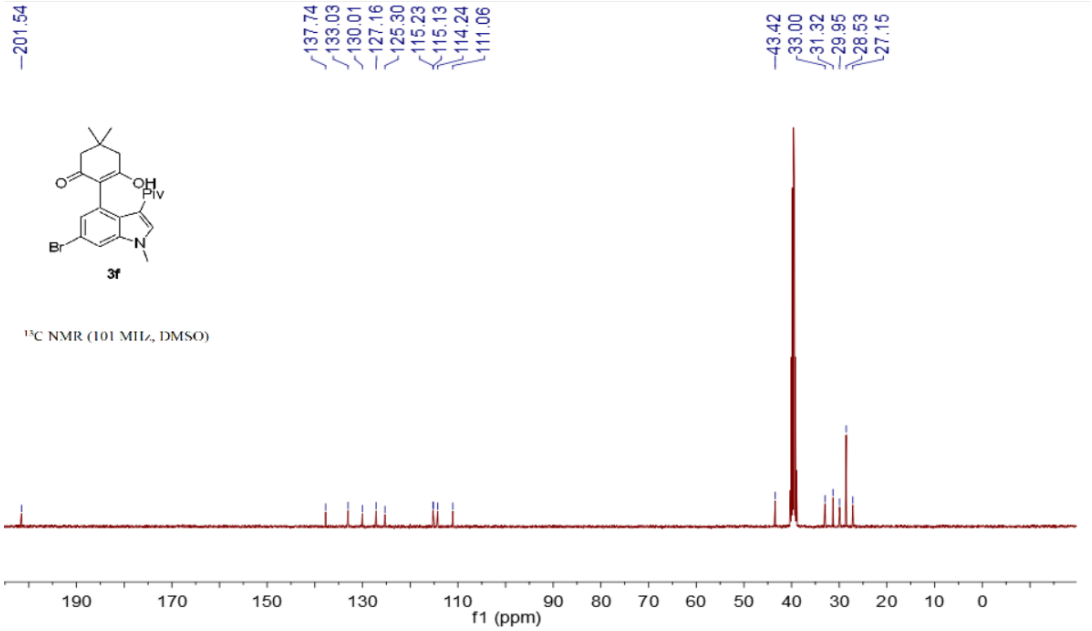
^{13}C NMR (101 MHz, DMSO) Spectra of **3e**



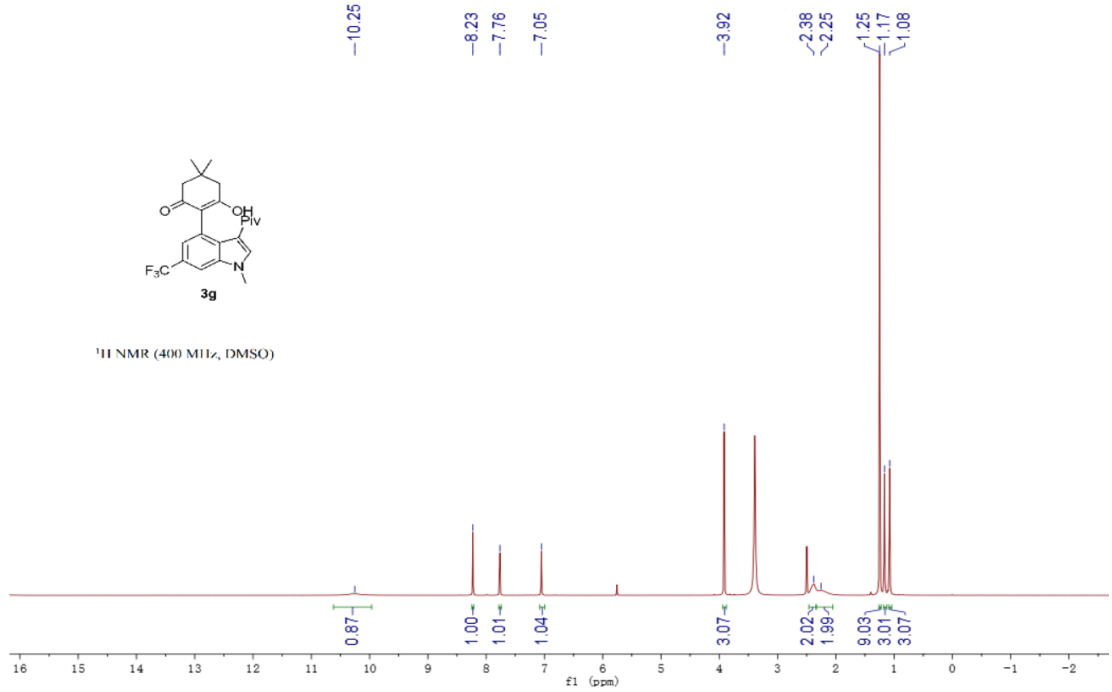
^{1}H NMR (400 MHz, DMSO) Spectra of **3f**



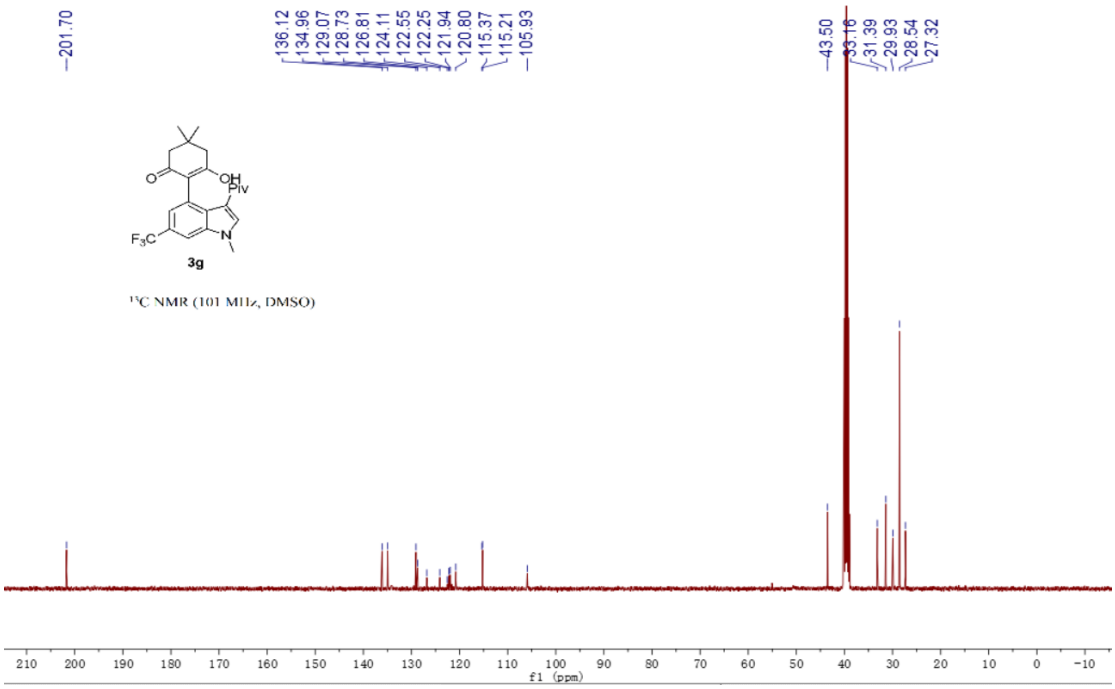
^{13}C NMR (101 MHz, DMSO) Spectra of **3f**



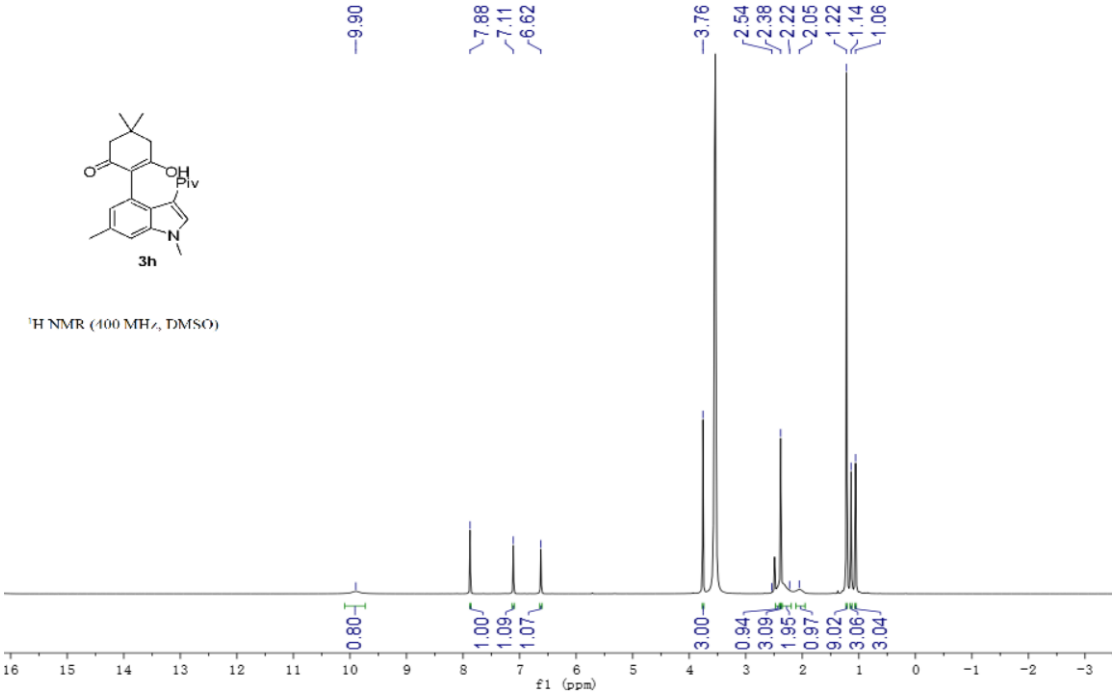
^{1}H NMR (400 MHz, DMSO) Spectra of **3g**



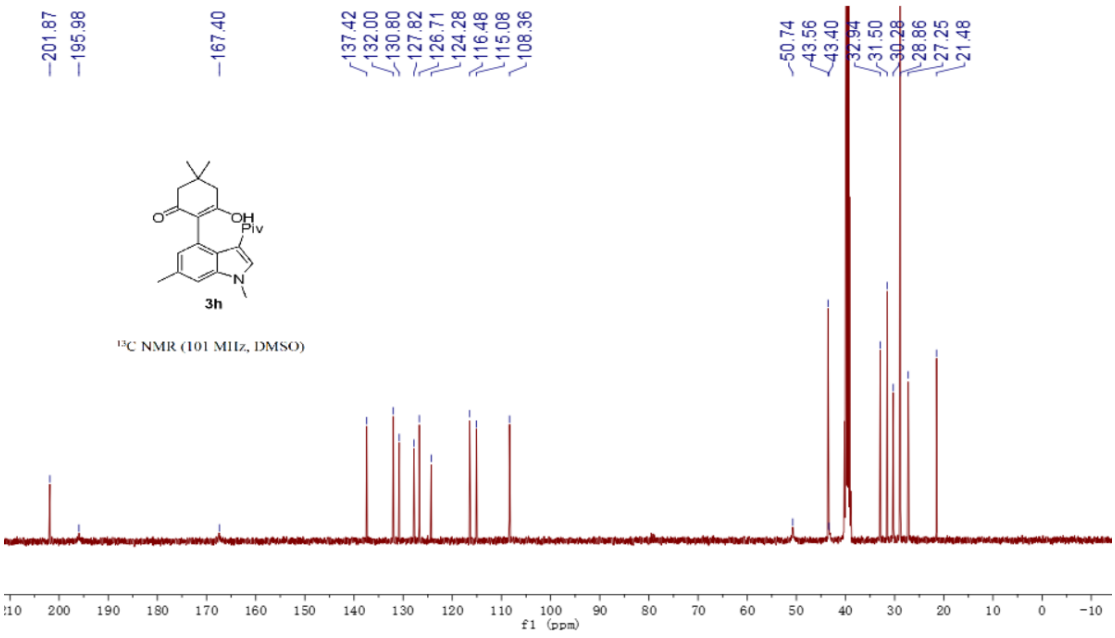
^{13}C NMR (101 MHz, DMSO) Spectra of **3g**



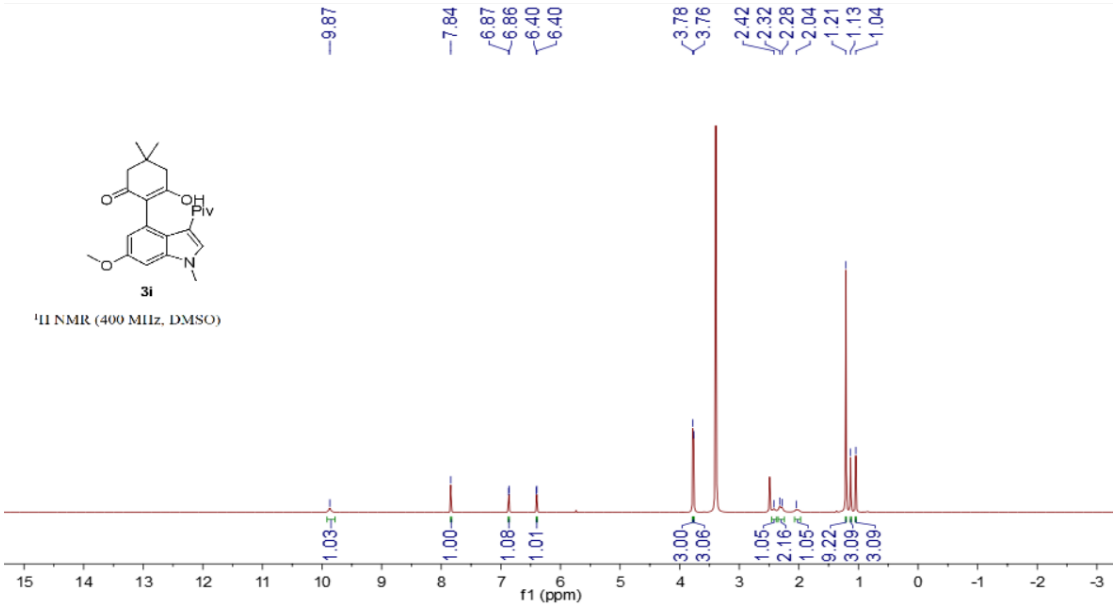
^{1}H NMR (400 MHz, DMSO) Spectra of **3h**



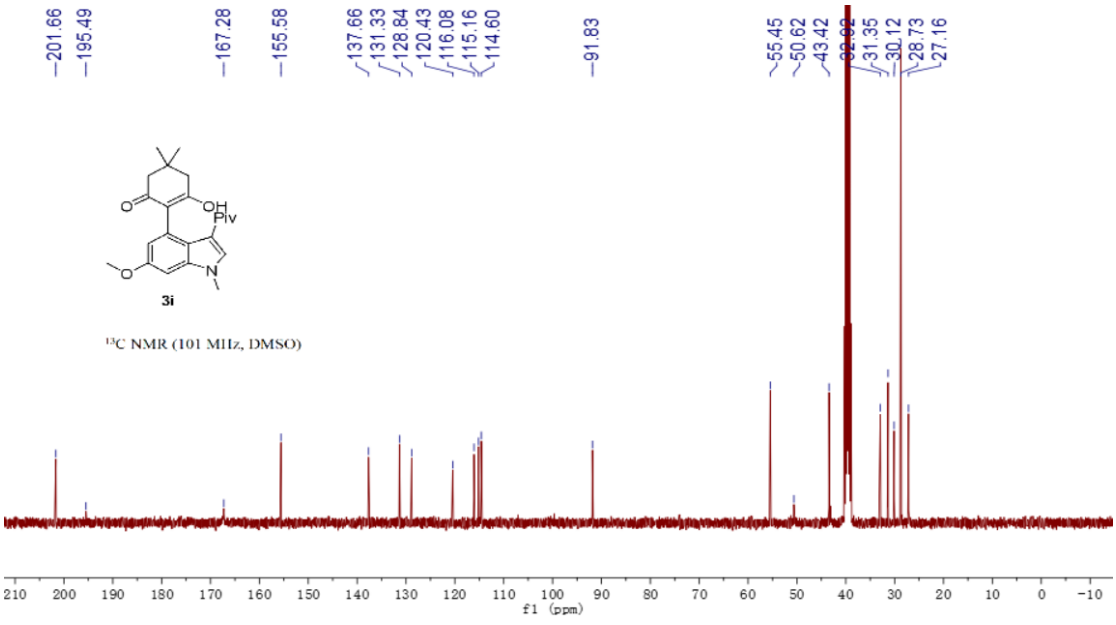
^{13}C NMR (101 MHz, DMSO) Spectra of **3h**



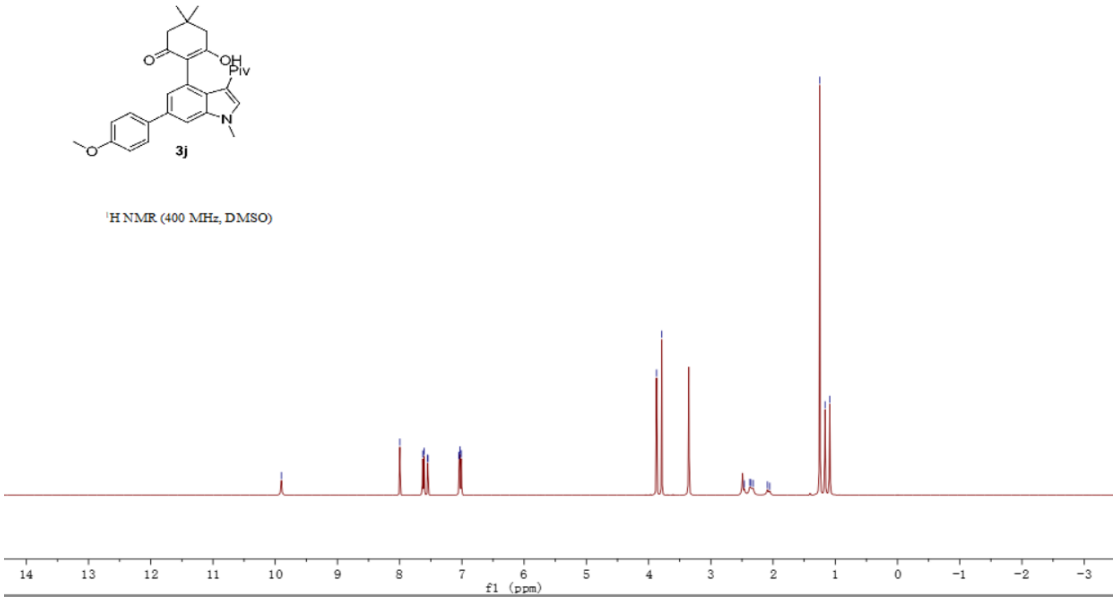
^{1}H NMR (400 MHz, DMSO) Spectra of **3i**



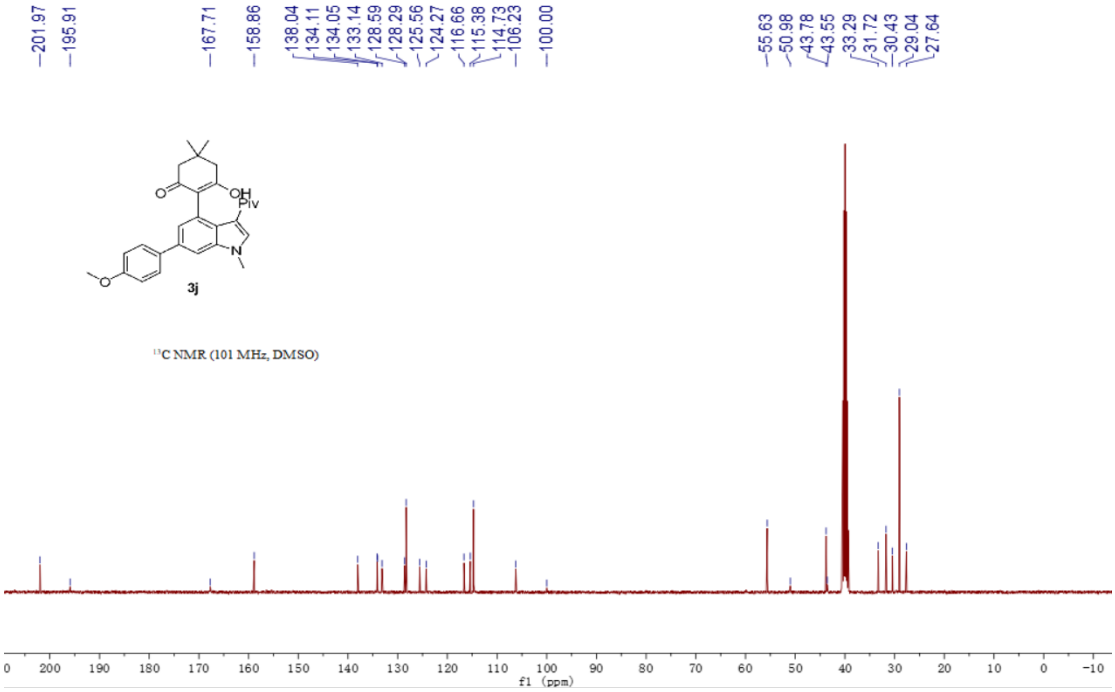
^{13}C NMR (101 MHz, DMSO) Spectra of **3i**



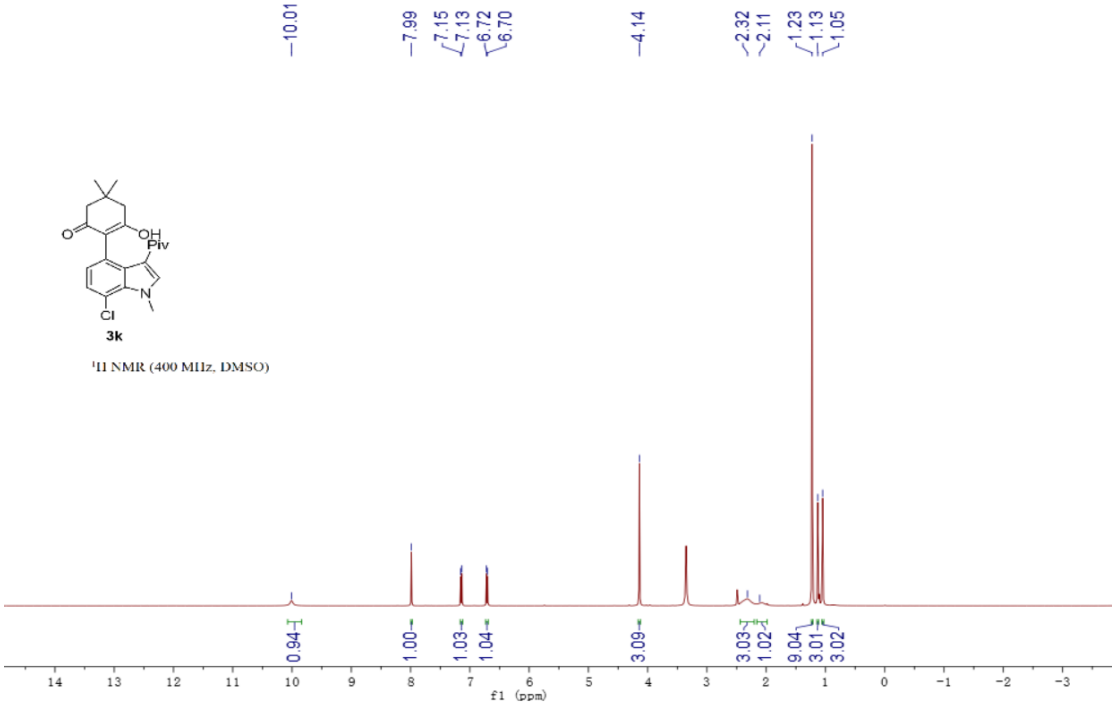
^{1}H NMR (400 MHz, DMSO) Spectra of **3j**



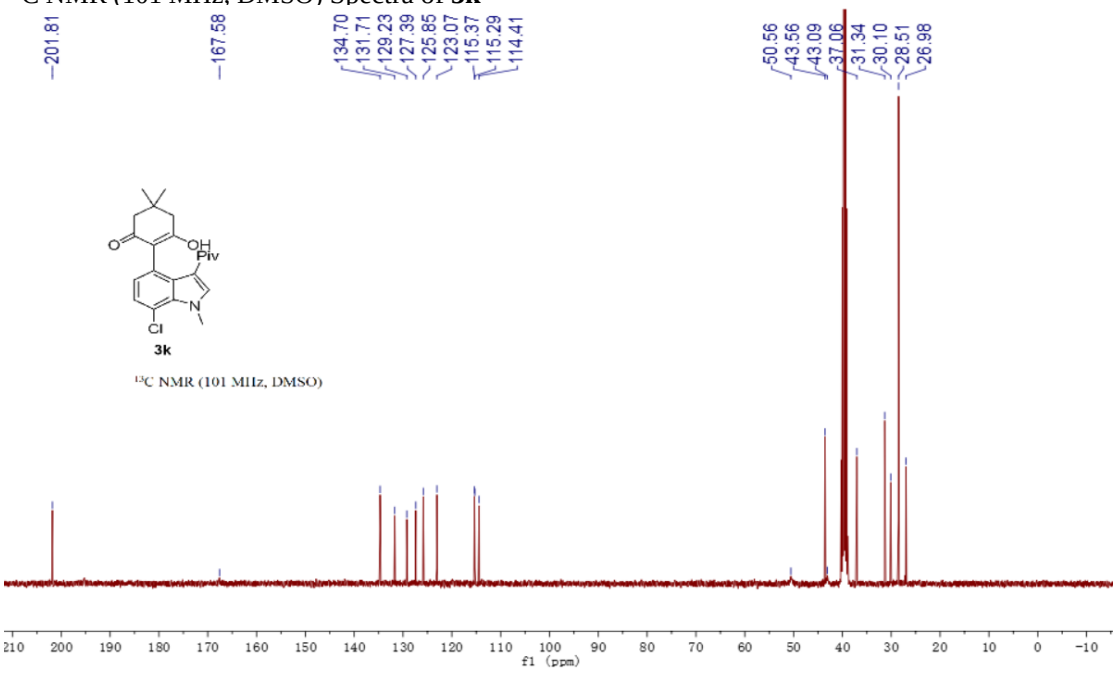
^{13}C NMR (101 MHz, DMSO) Spectra of **3j**



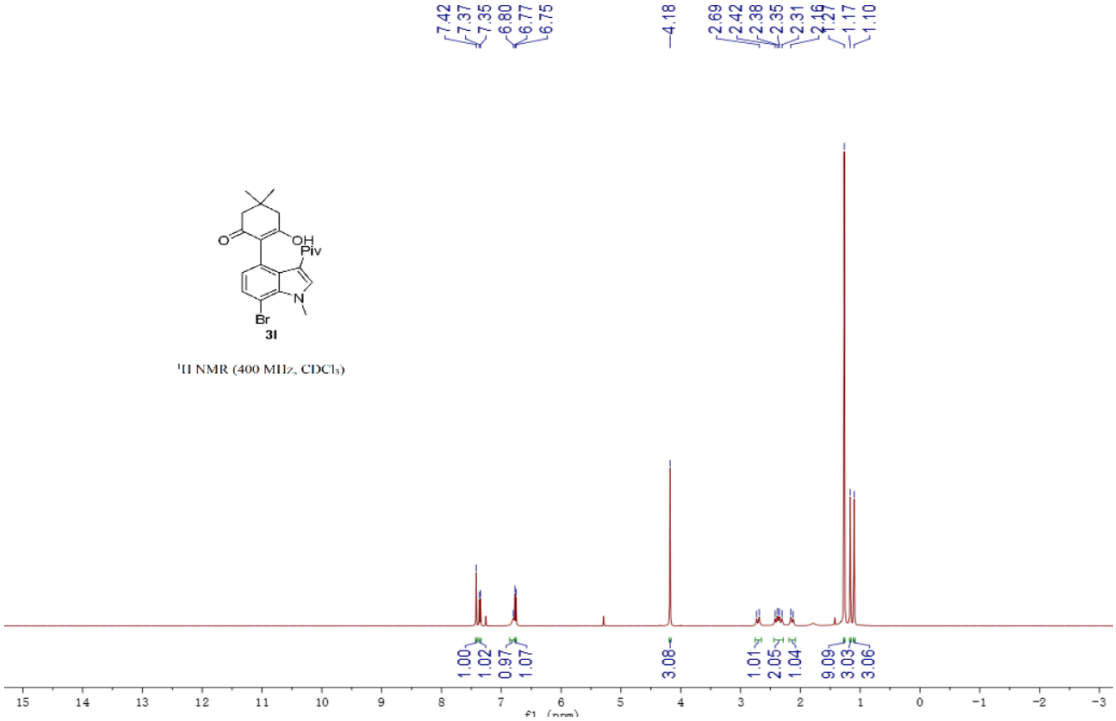
^{1}H NMR (400 MHz, DMSO) Spectra of **3k**



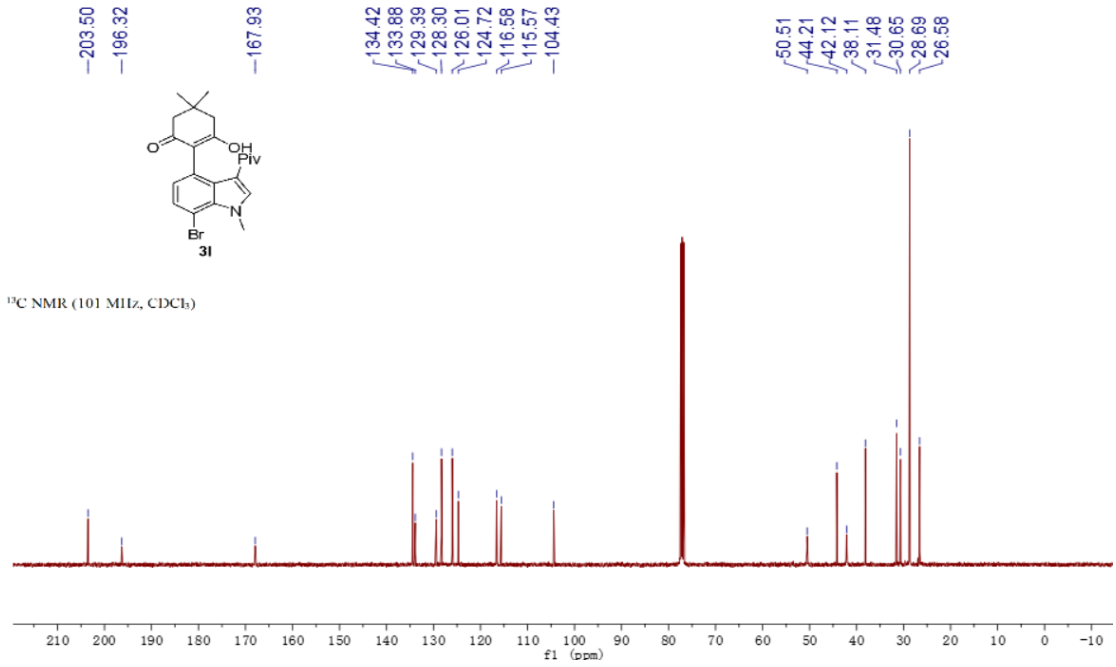
^{13}C NMR (101 MHz, DMSO) Spectra of **3k**



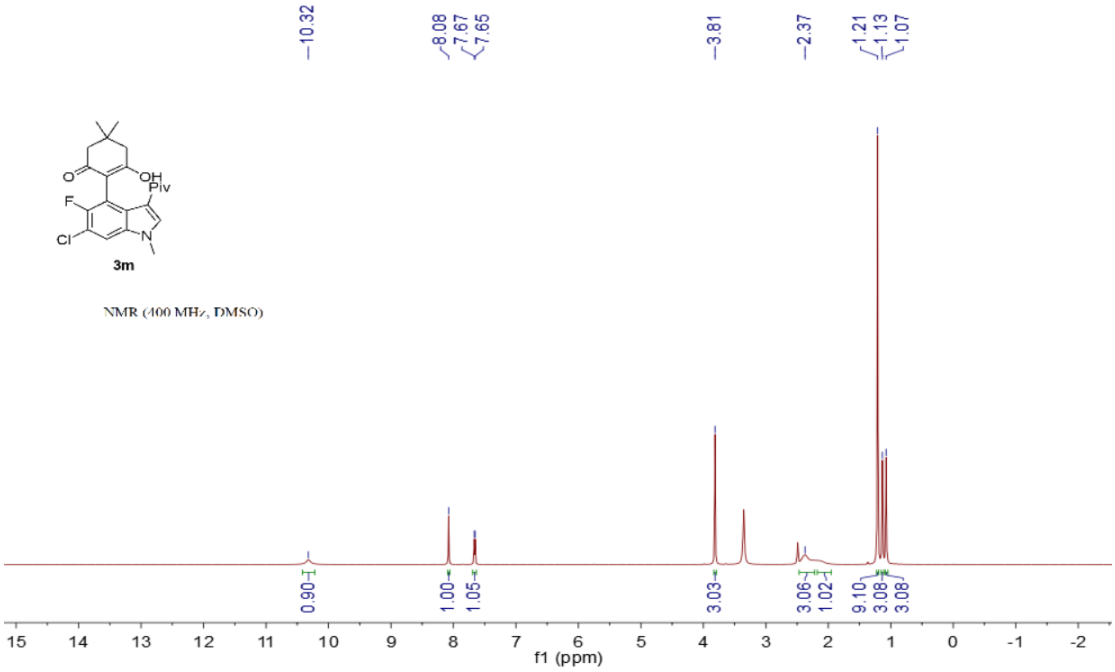
^{1}H NMR (400 MHz, $CDCl_3$) Spectra of **3l**



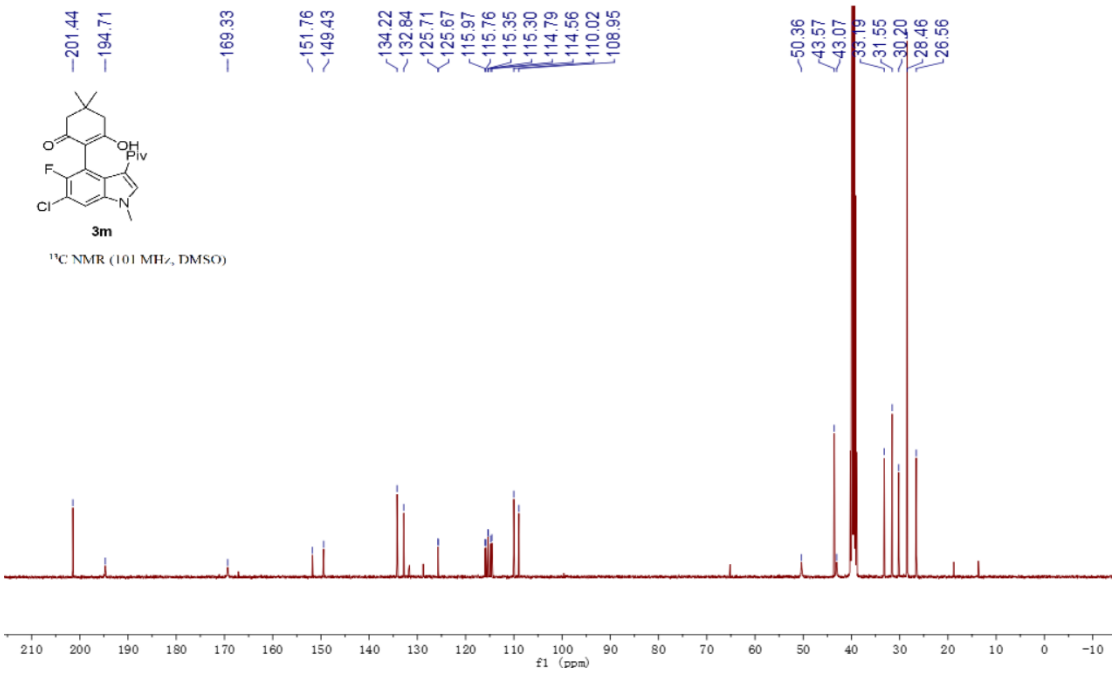
^{13}C NMR (101 MHz, $CDCl_3$) Spectra of **3l**



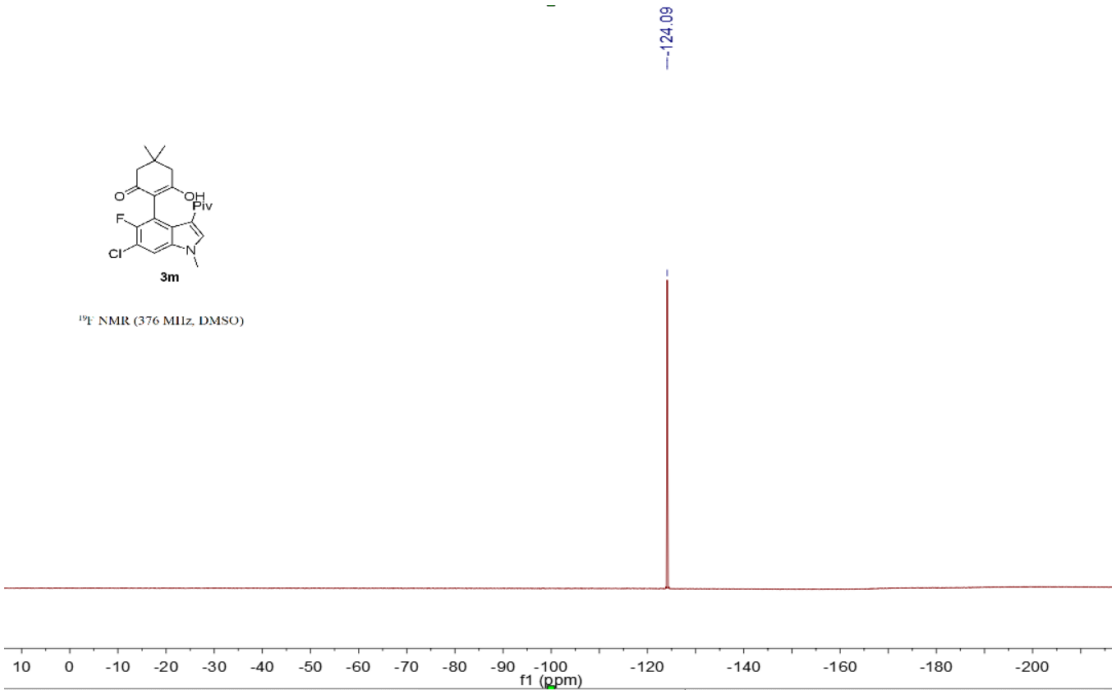
^{1}H NMR (400 MHz, DMSO) Spectra of **3m**



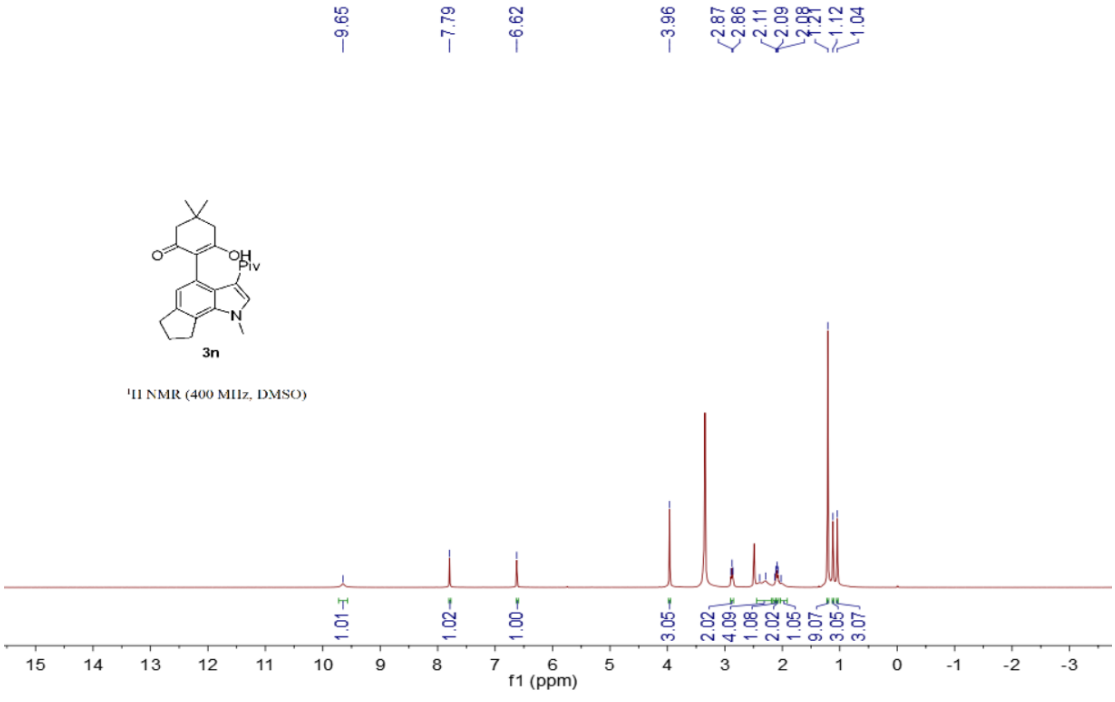
^{13}C NMR (101 MHz, DMSO) Spectra of **3m**



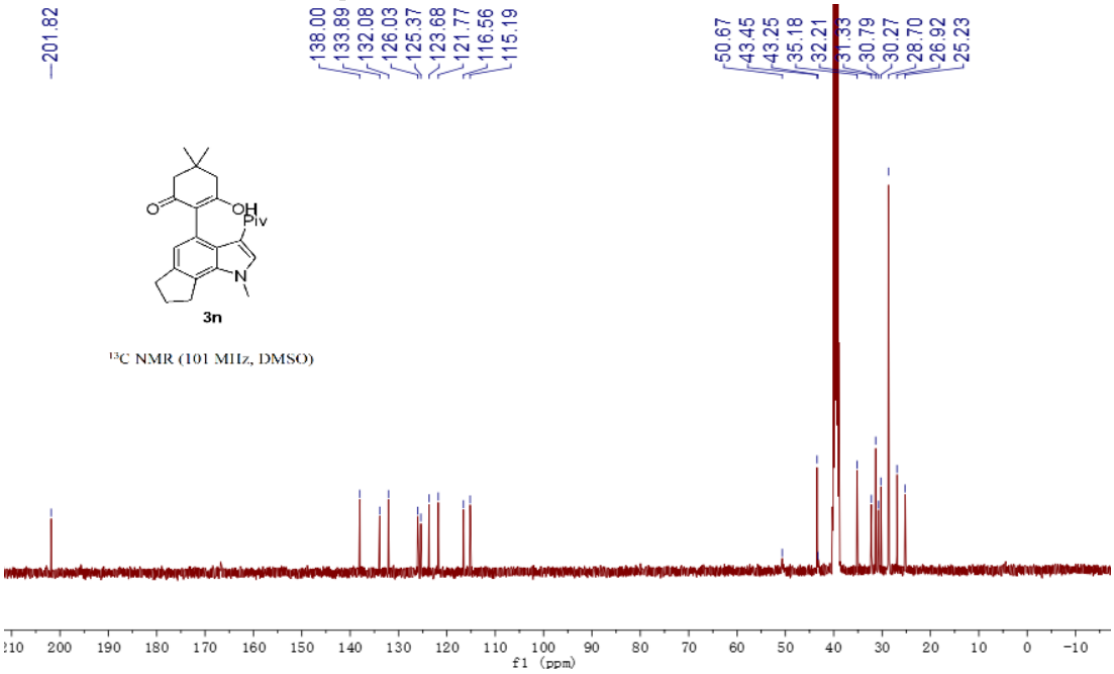
^{19}F NMR (376 MHz, DMSO) Spectra of **3m**



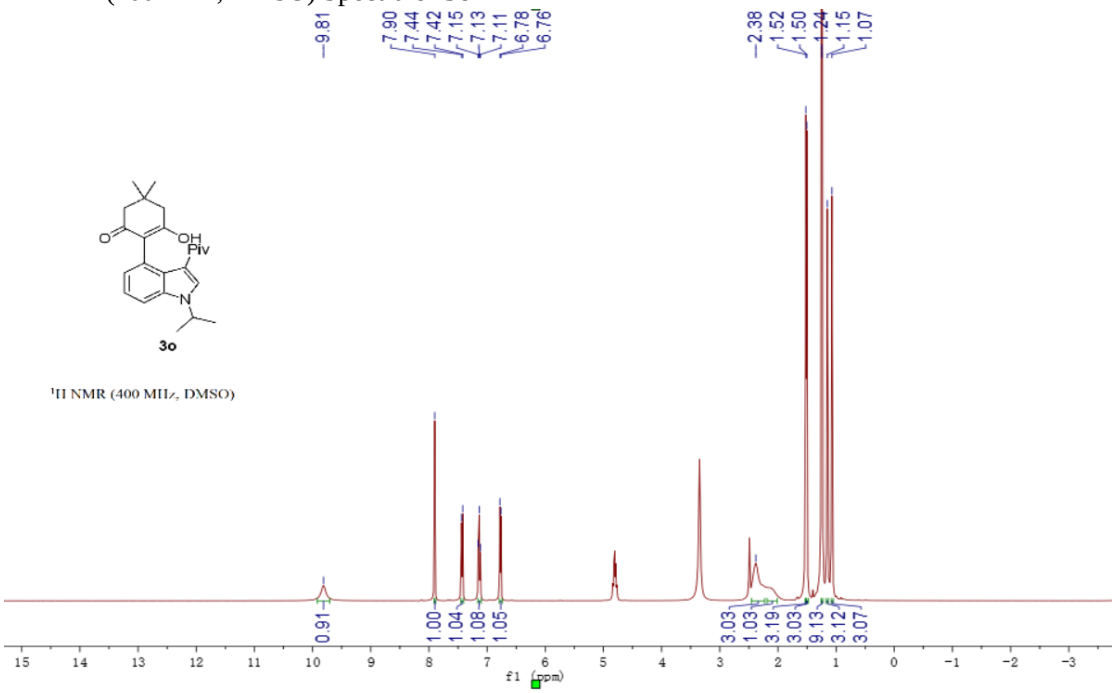
^{1}H NMR (400 MHz, DMSO) Spectra of **3n**



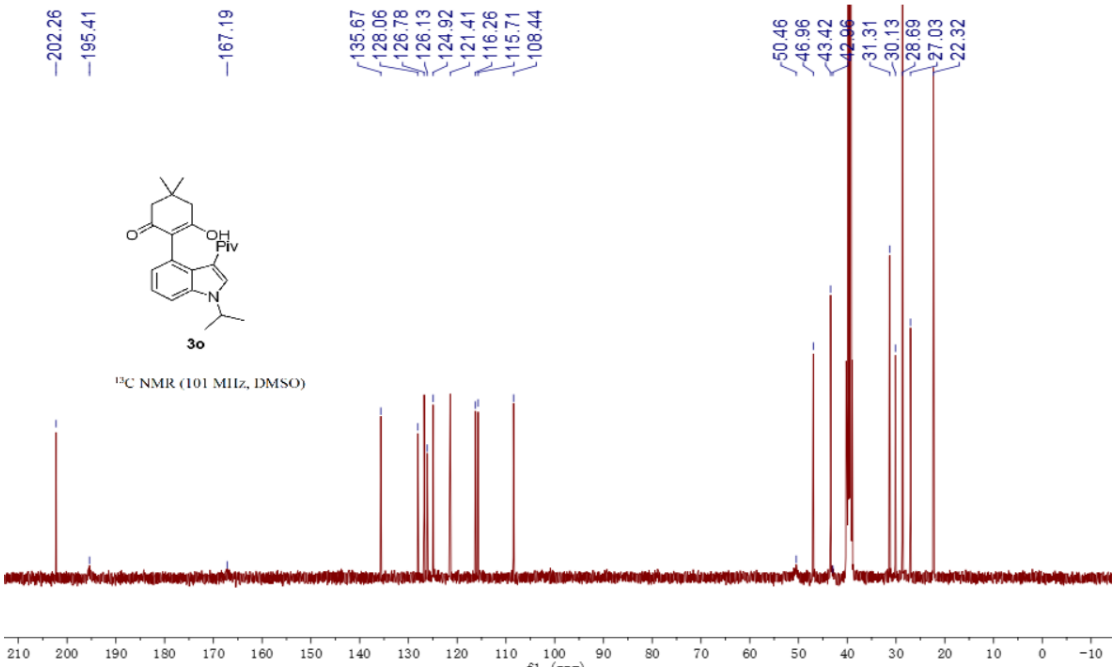
^{13}C NMR (101 MHz, $CDCl_3$) Spectra of **3n**



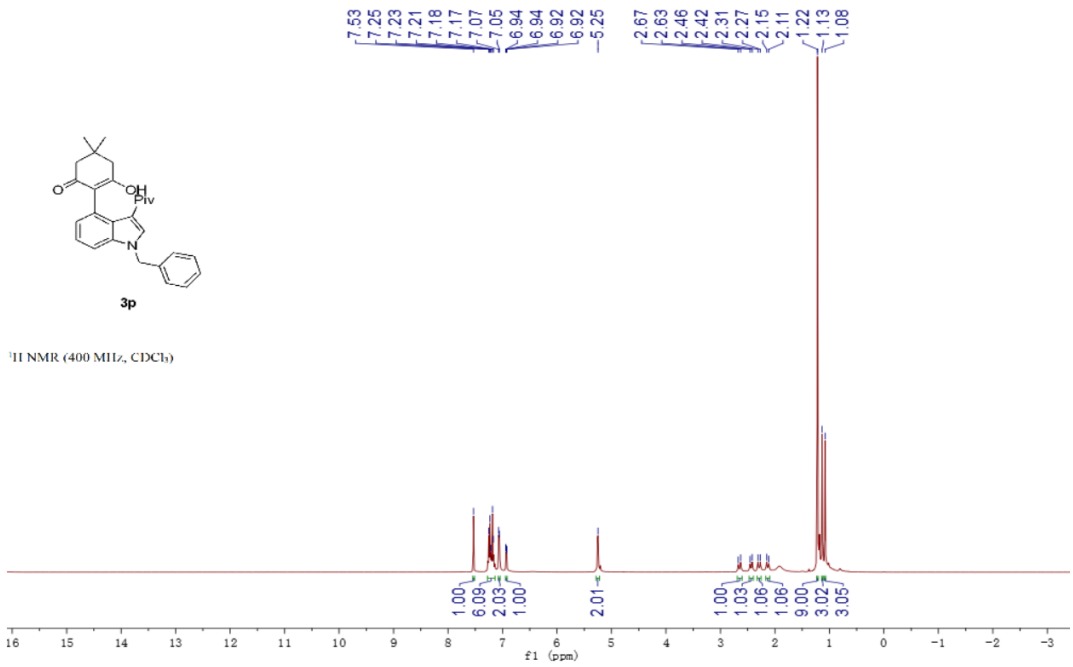
^{1}H NMR (400 MHz, DMSO) Spectra of **3o**



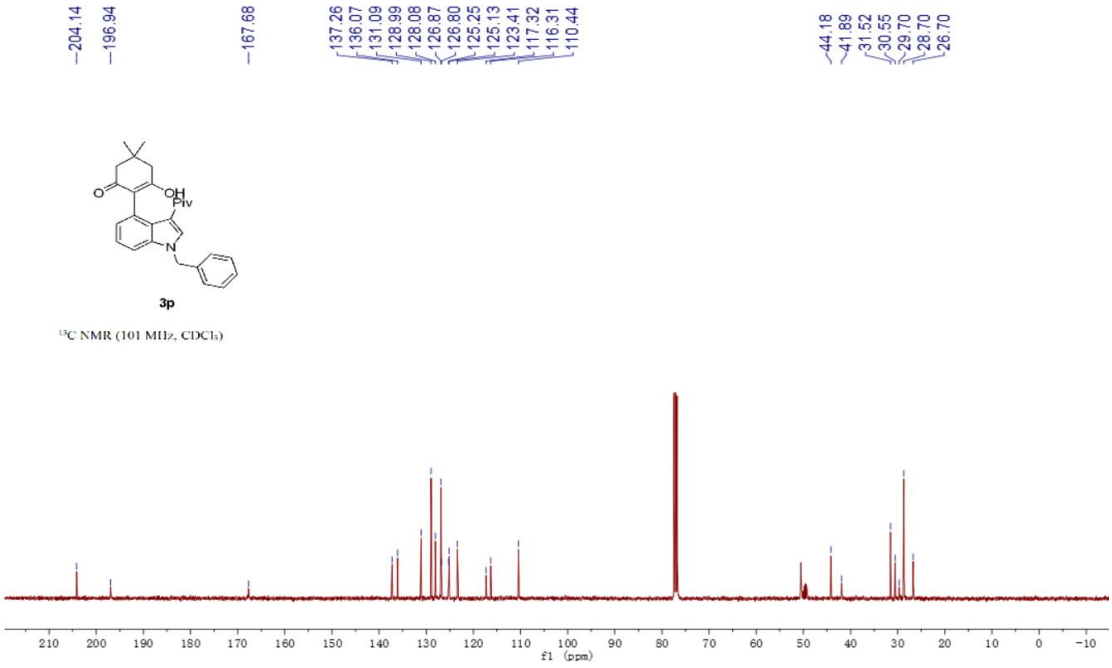
^{13}C NMR (101 MHz, DMSO) Spectra of **3o**



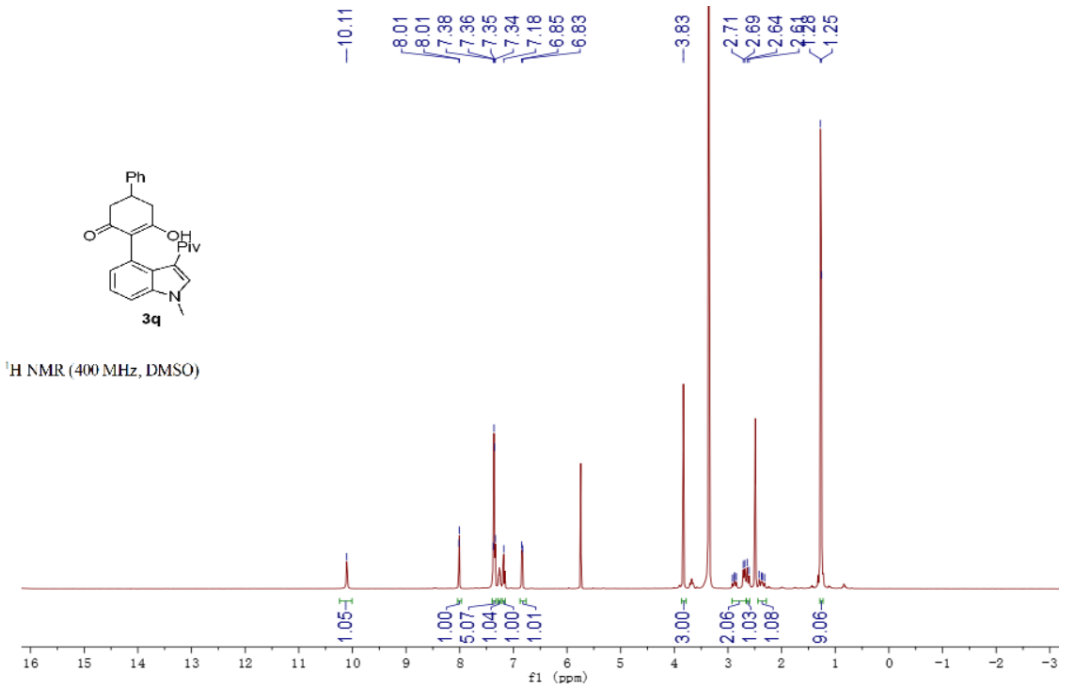
^{1}H NMR (400 MHz, $CDCl_3$) Spectra of **3p**



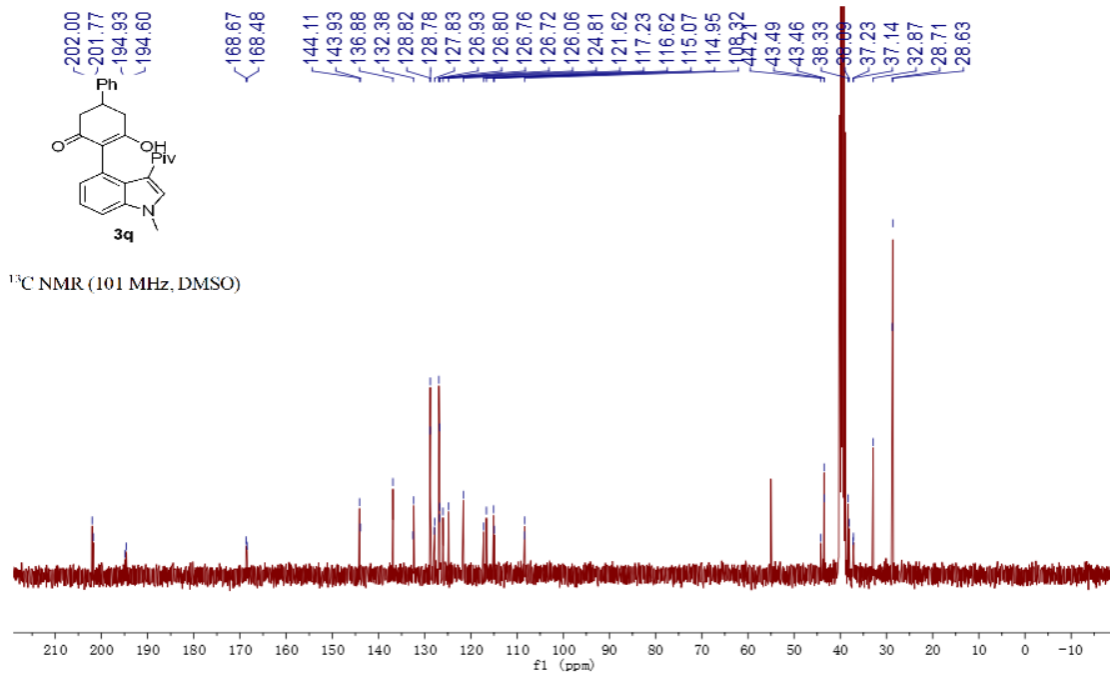
^{13}C NMR (101 MHz, $CDCl_3$) Spectra of **3p**



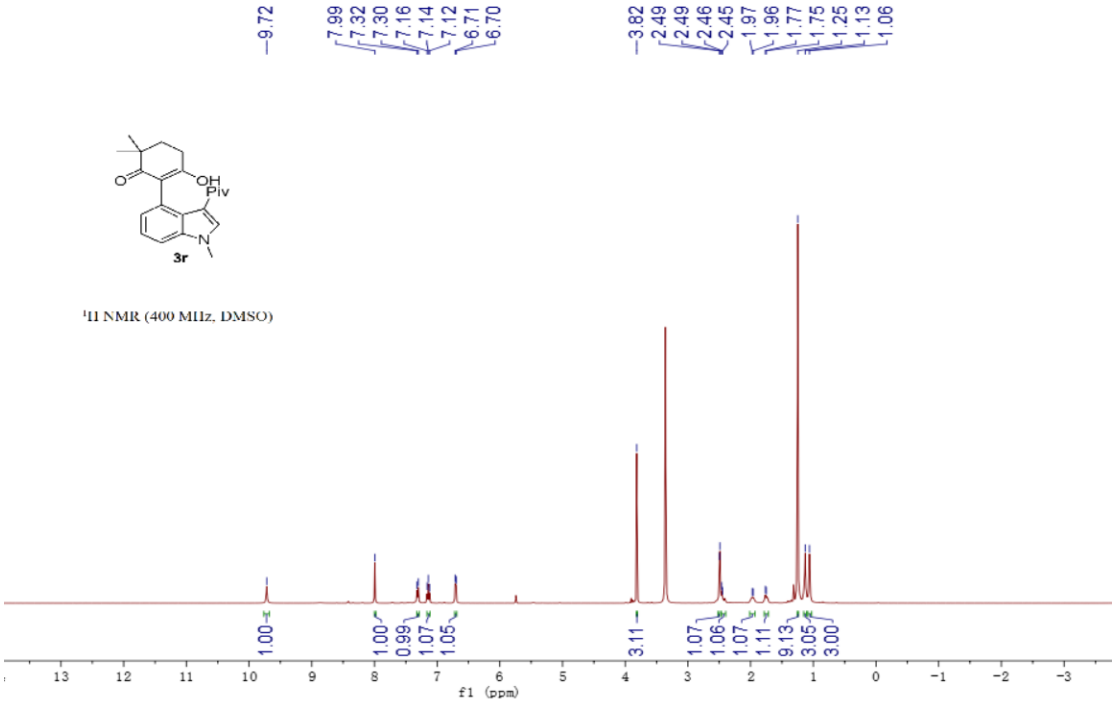
^{1}H NMR (400 MHz, DMSO) Spectra of **3q**



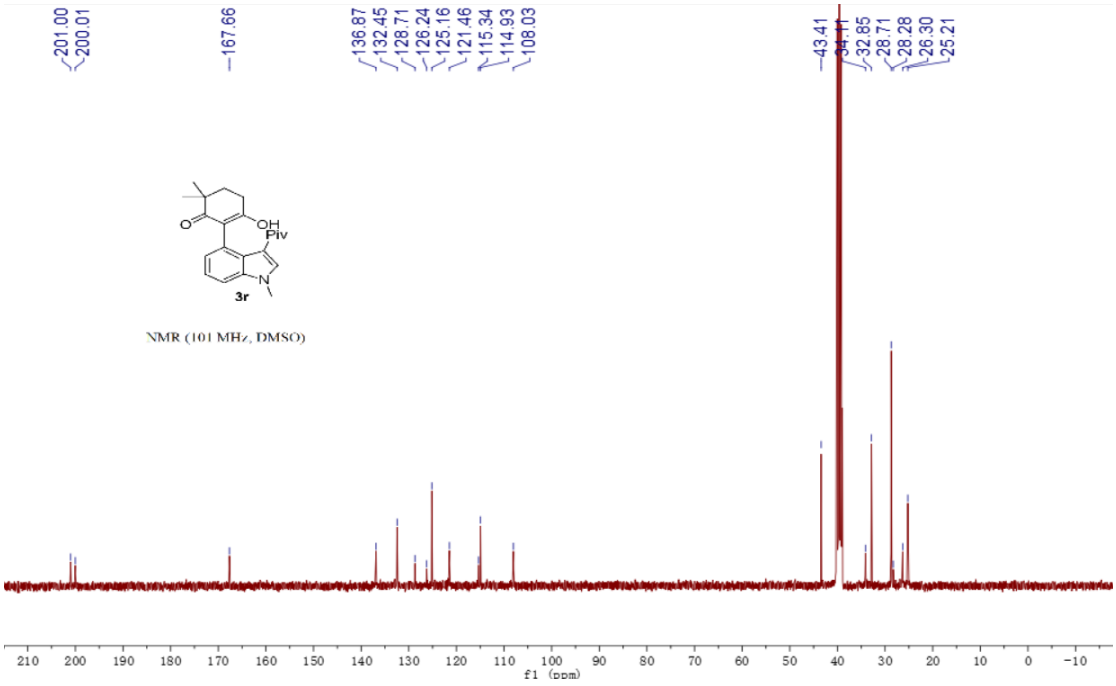
^{13}C NMR (101 MHz, DMSO) Spectra of **3q**



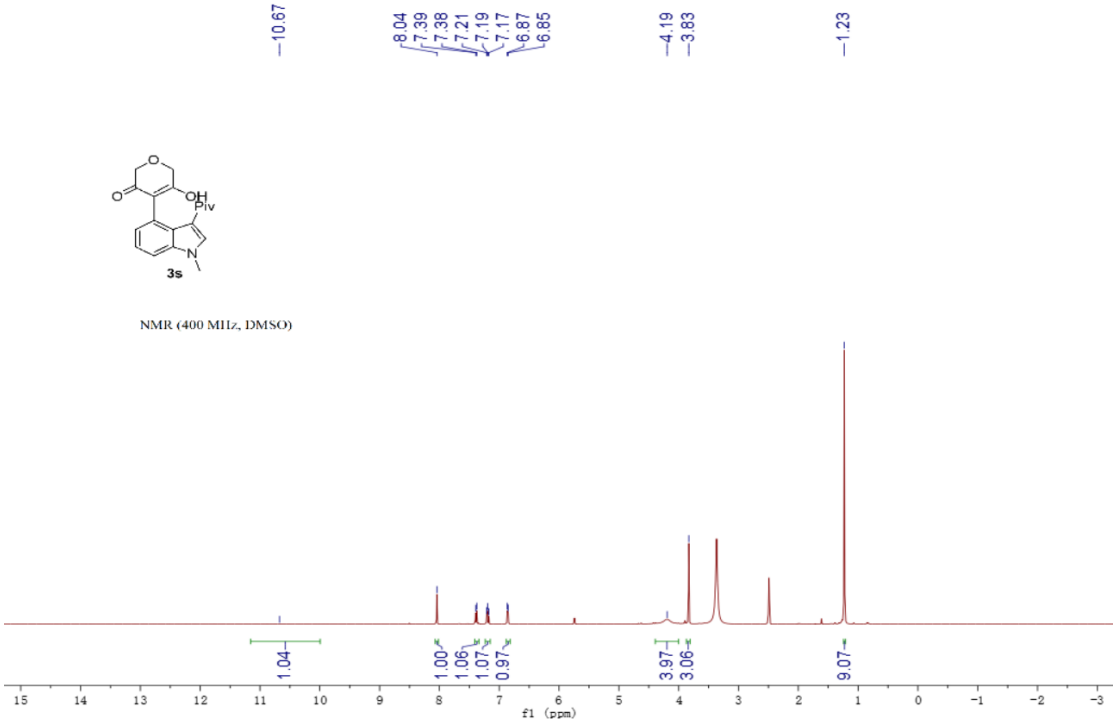
^{1}H NMR (400 MHz, DMSO) Spectra of **3r**



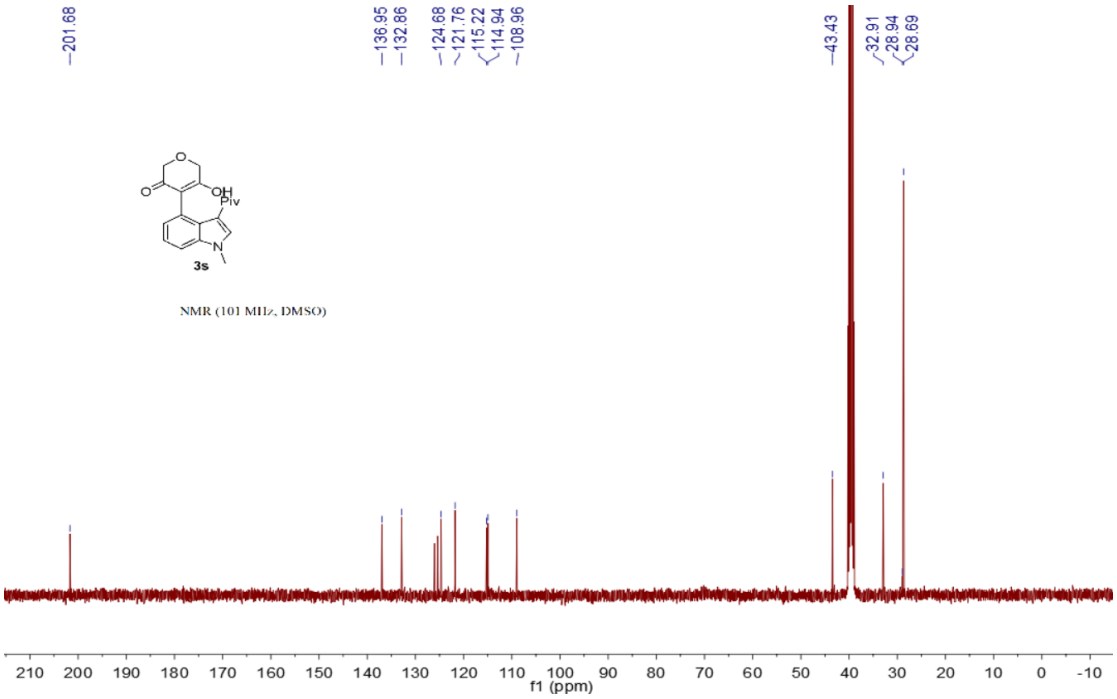
^{13}C NMR (101 MHz, DMSO) Spectra of **3r**



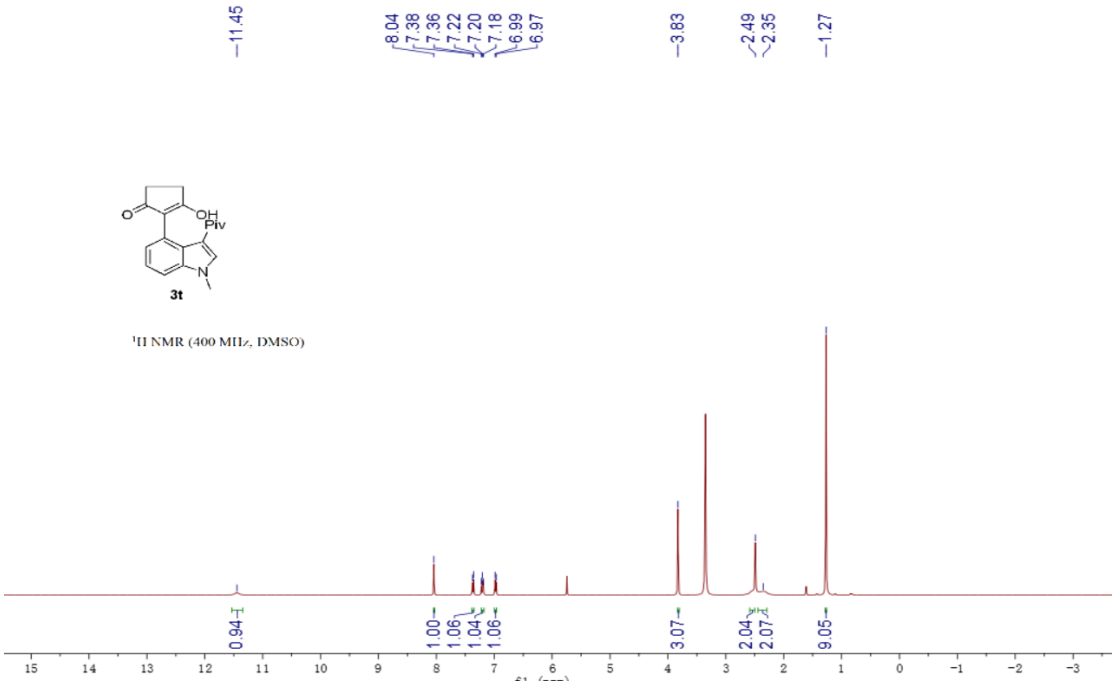
^{1}H NMR (400 MHz, DMSO) Spectra of **3s**



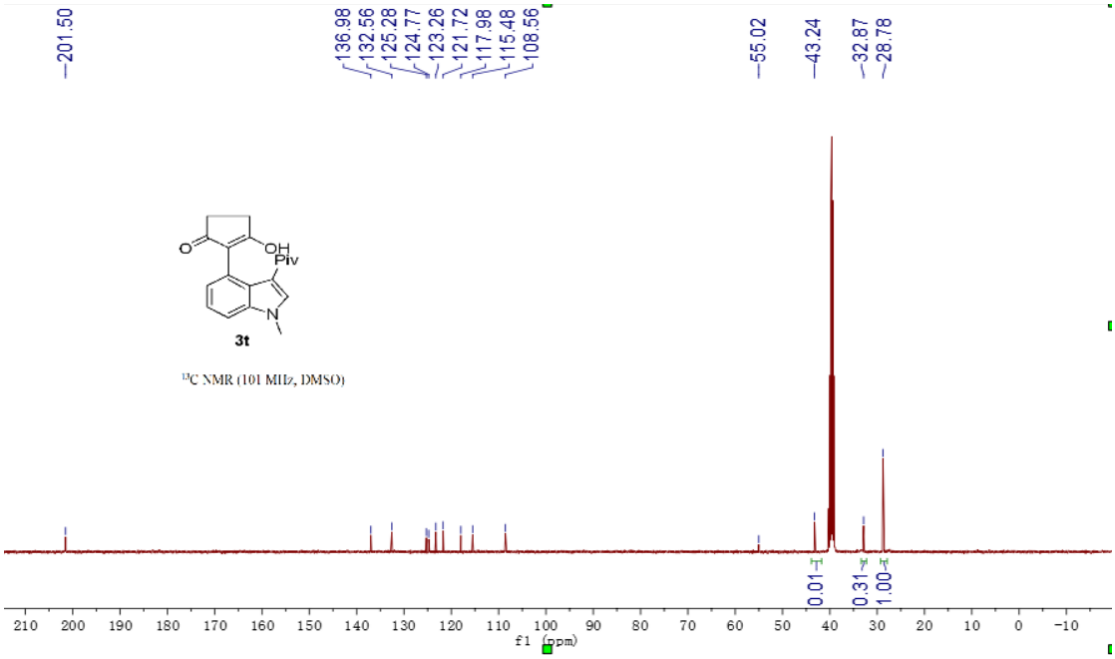
^{13}C NMR (101 MHz, DMSO) Spectra of **3s**



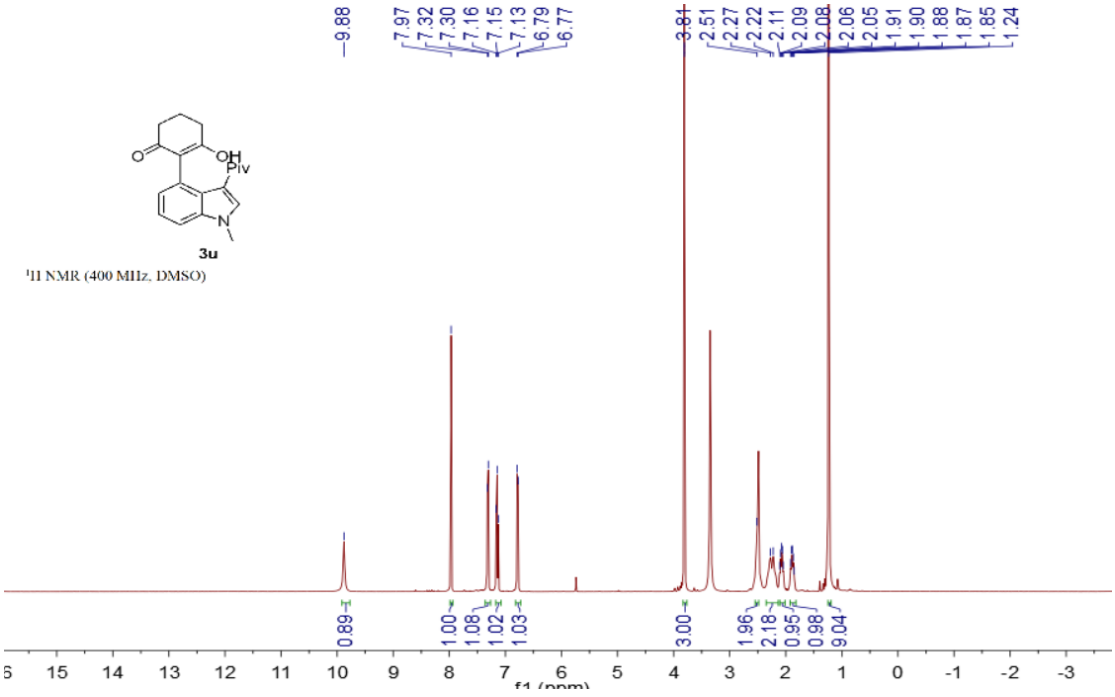
^{1}H NMR (400 MHz, DMSO) Spectra of **3t**



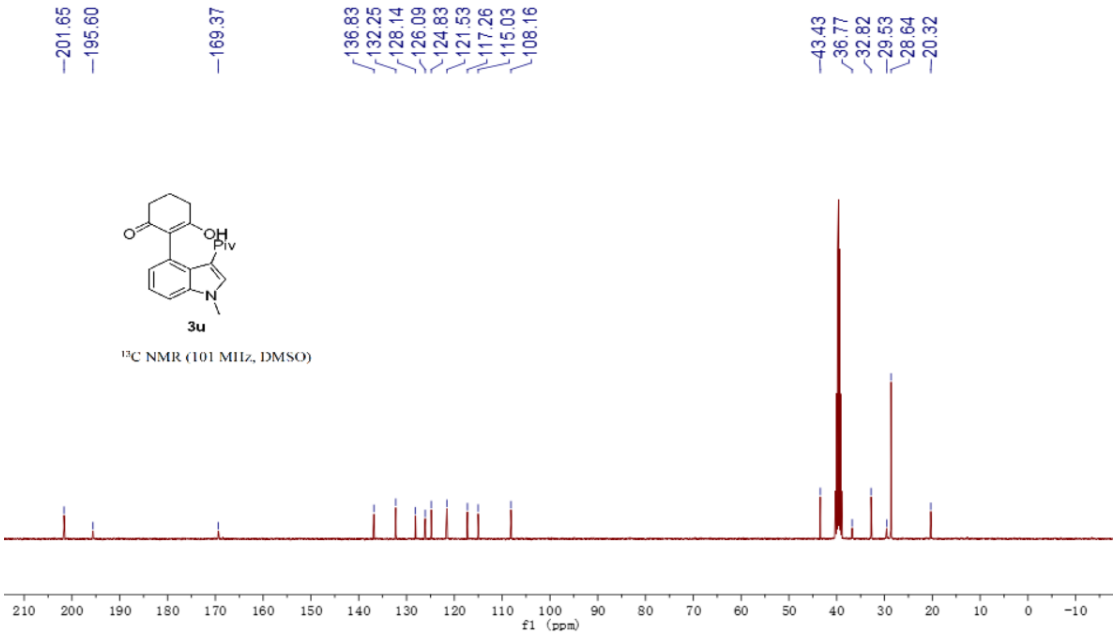
^{13}C NMR (101 MHz, DMSO) Spectra of **3t**



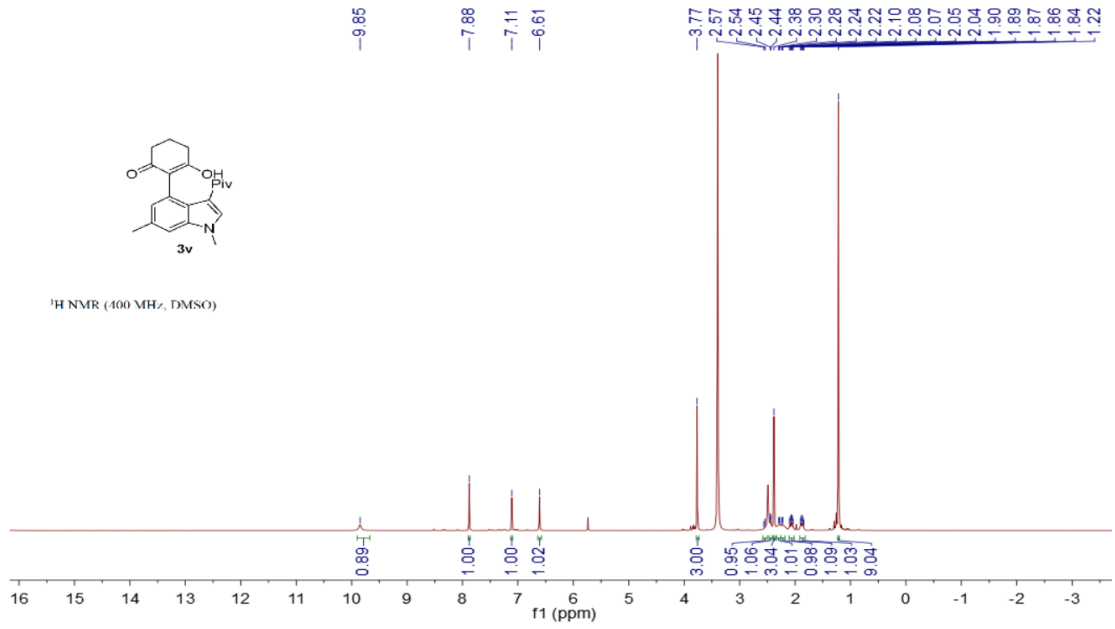
^{1}H NMR (400 MHz, DMSO) Spectra of **3u**



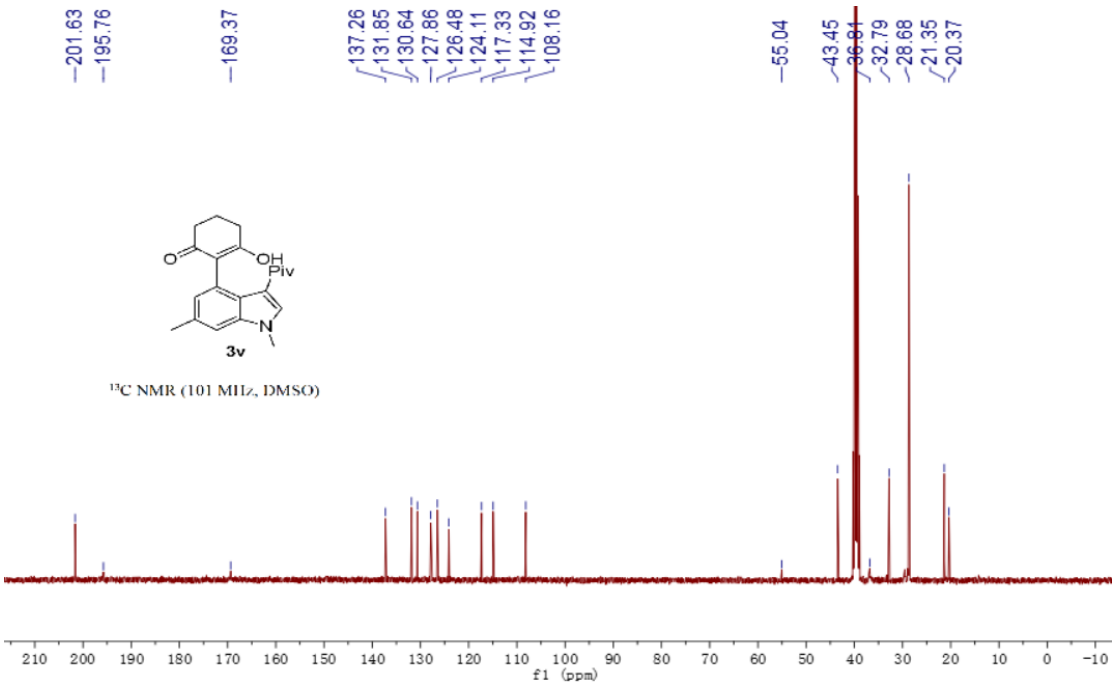
^{13}C NMR (101 MHz, DMSO) Spectra of **3u**



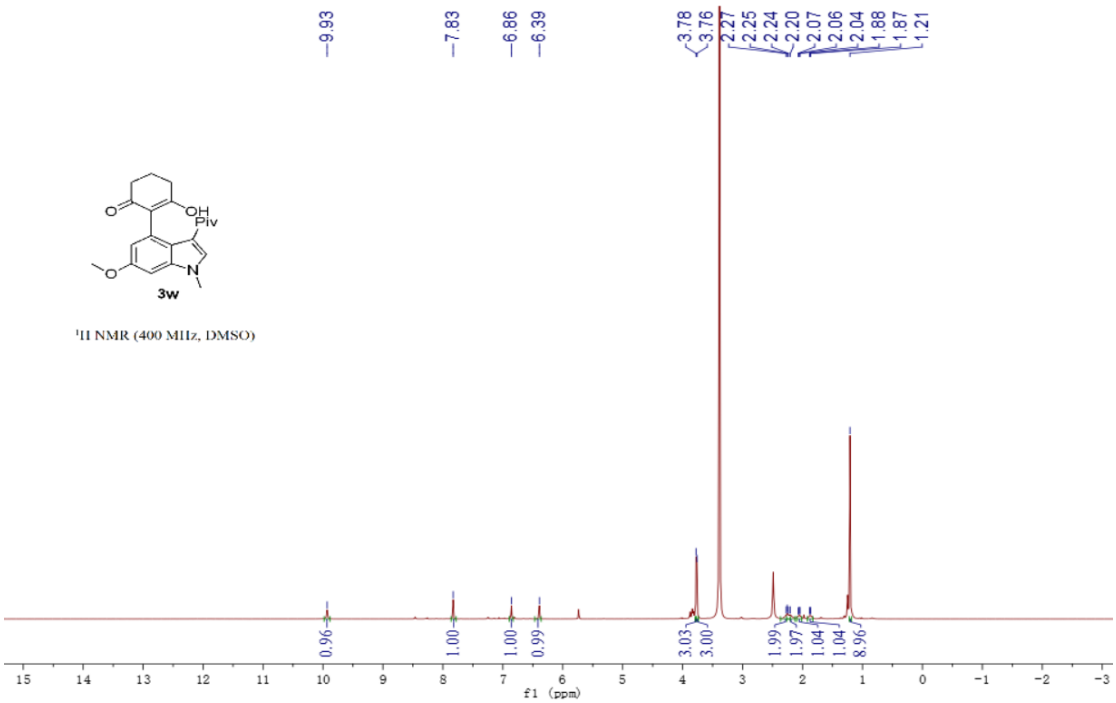
^{1}H NMR (400 MHz, DMSO) Spectra of **3v**



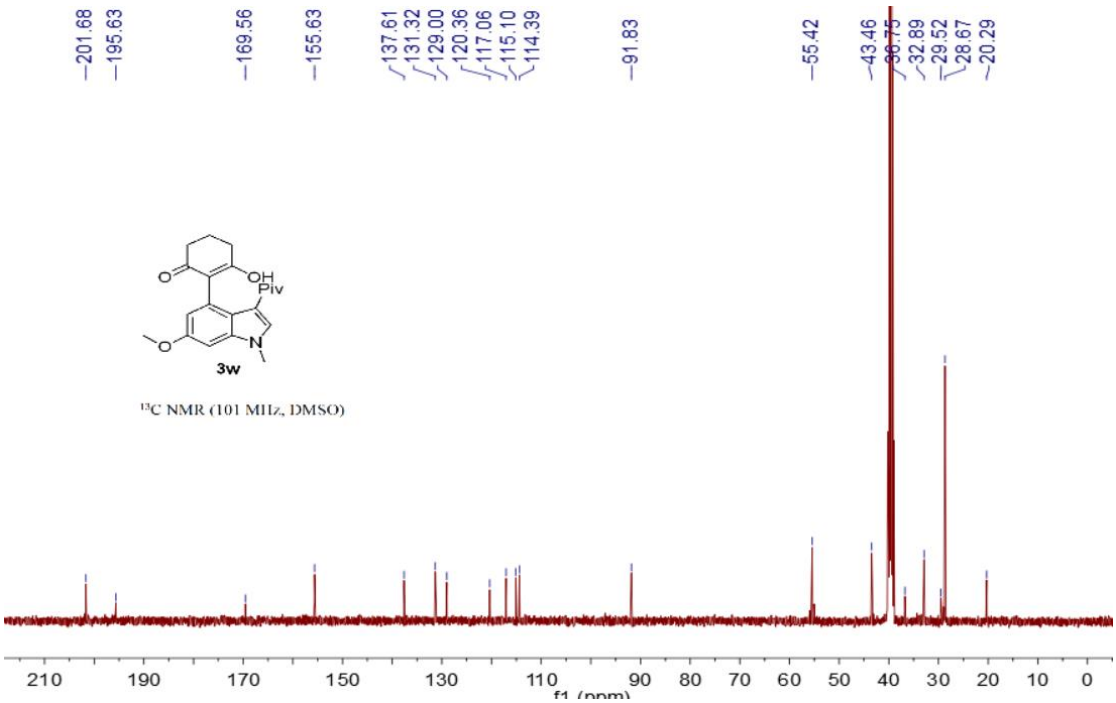
^{13}C NMR (101 MHz, DMSO) Spectra of **3v**



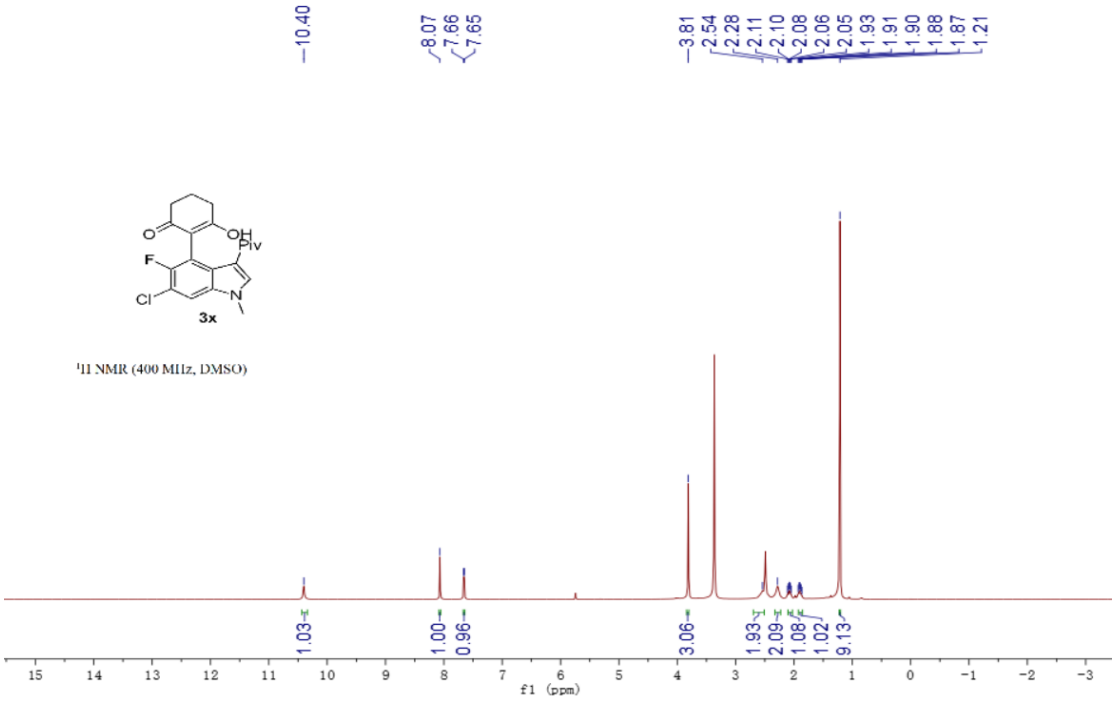
^{1}H NMR (400 MHz, DMSO) Spectra of **3w**



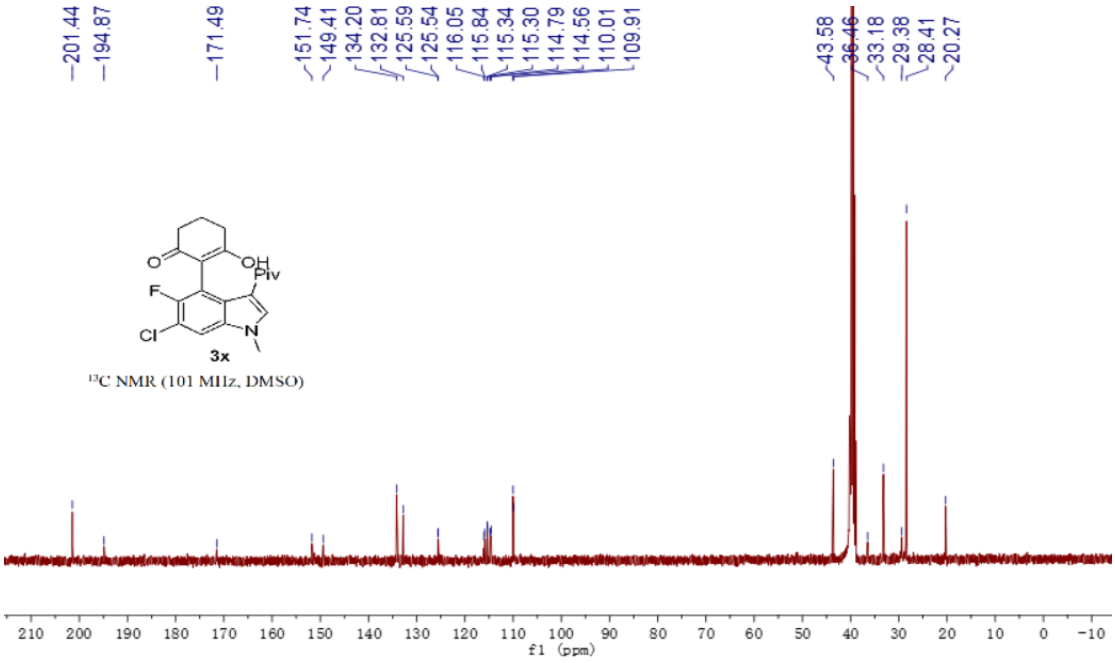
^{13}C NMR (101 MHz, DMSO) Spectra of **3w**



^{1}H NMR (400 MHz, DMSO) Spectra of **3x**

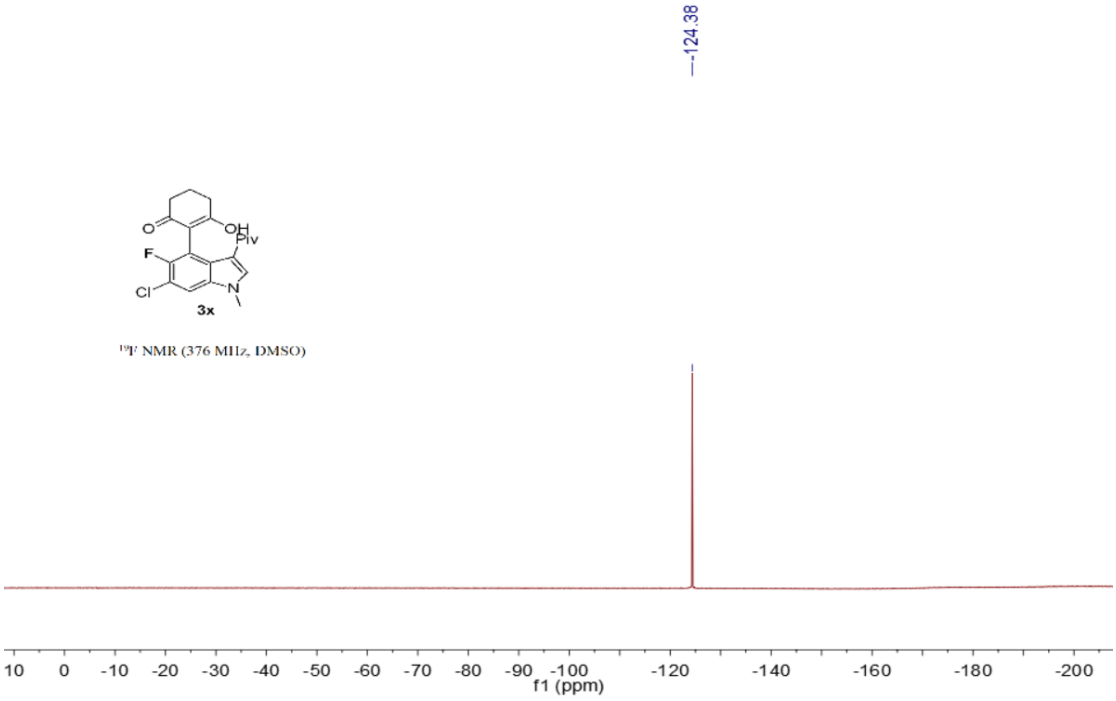


^{13}C NMR (101 MHz, DMSO) Spectra of **3x**



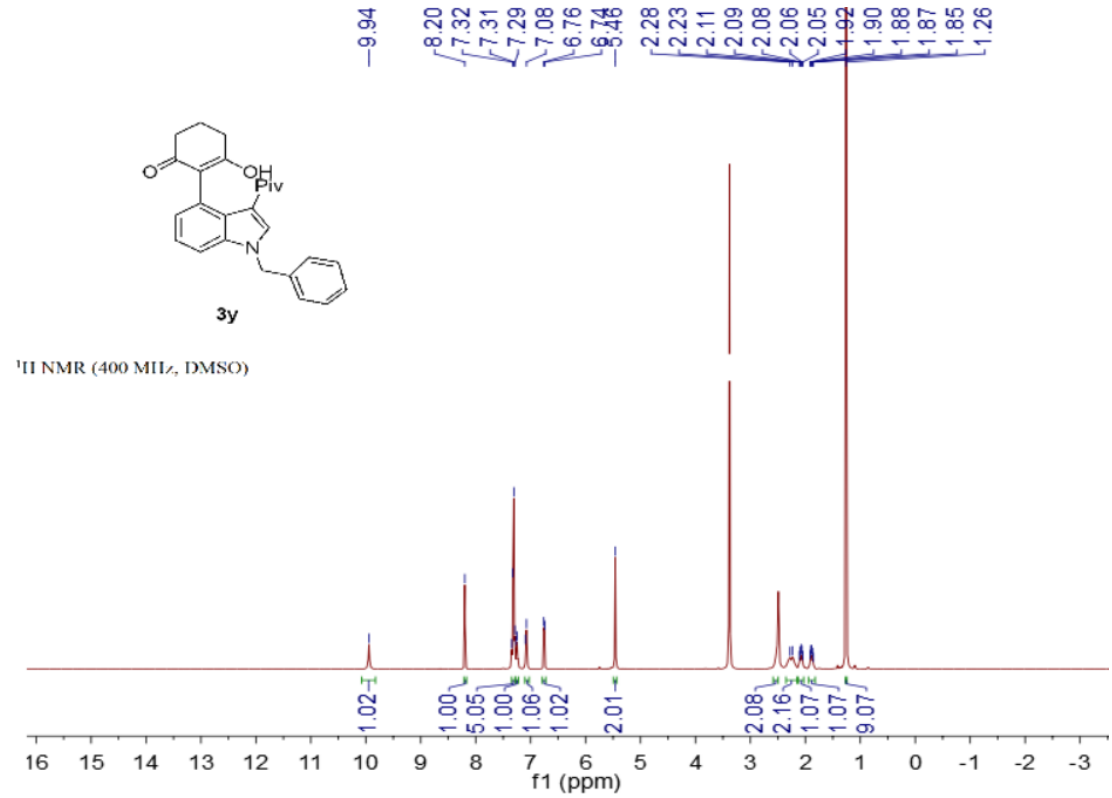
^{13}C NMR (101 MHz, DMSO)

^{19}F NMR (376 MHz, DMSO) Spectra of **3x**

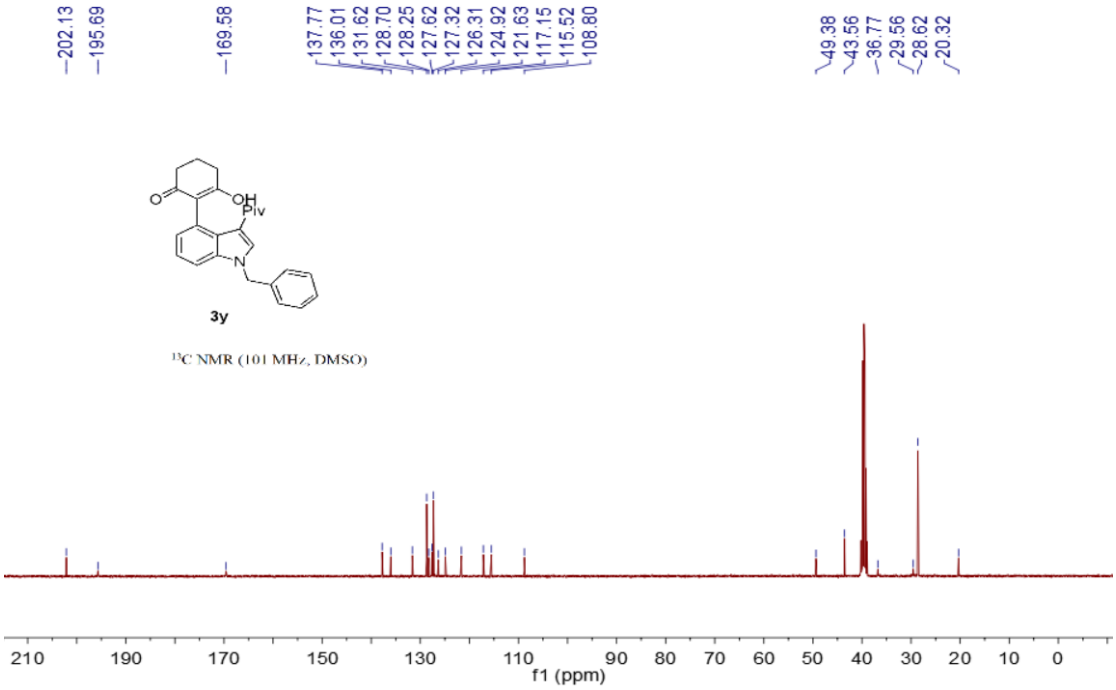


^{19}F NMR (376 MHz, DMSO)

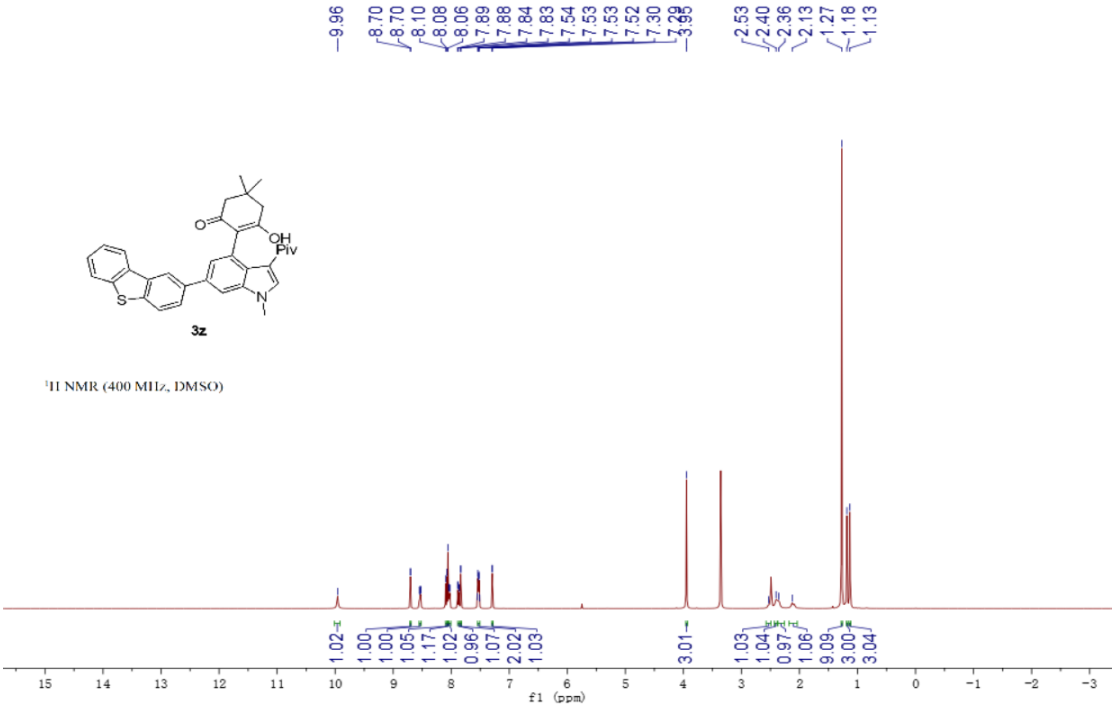
^{1}H NMR (400 MHz, DMSO) Spectra of **3y**



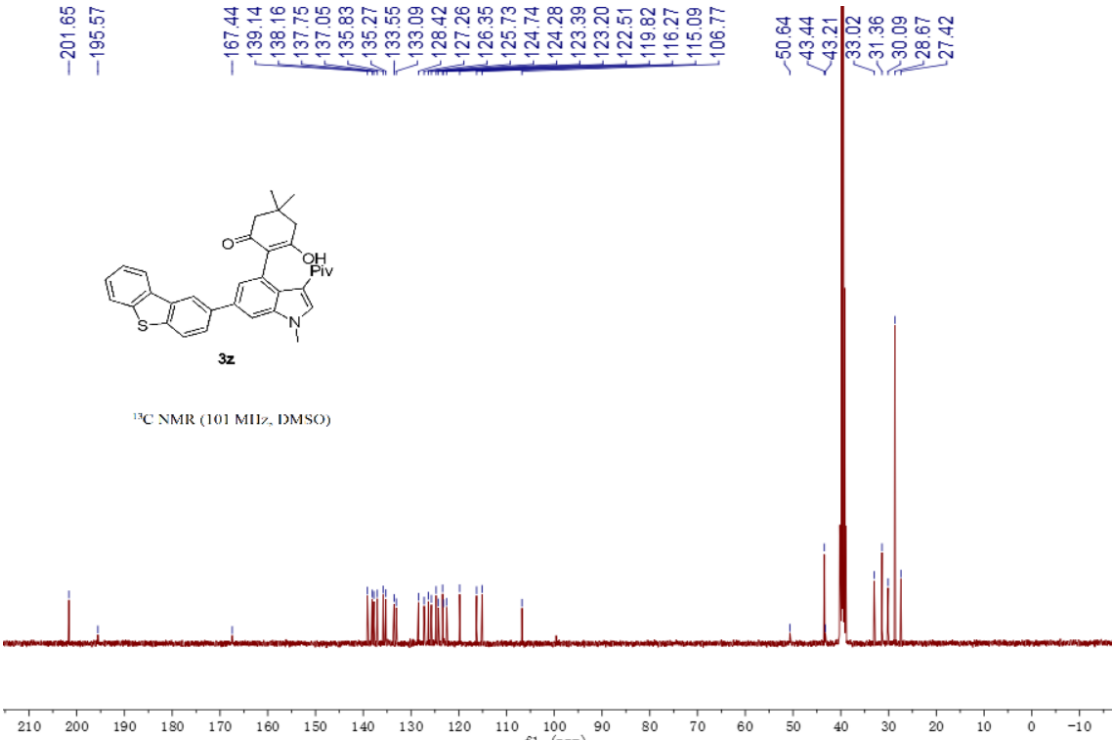
^{13}C NMR (101 MHz, DMSO) Spectra of **3y**



^{1}H NMR (400 MHz, DMSO) Spectra of **3z**



^{13}C NMR (101 MHz, DMSO) Spectra of **3z**



8. Reference

[1] J. Lv, X. Chen, X.-S. Xue, B. Zhao, Y. Liang, M. Wang, L. Jin, Y. Yuan, Y. Han, Y. Zhao, Y. Lu, J. Zhao, W.-Y. Sun, K. N. Houk and Z. Shi, *Nature*, **2019**, *575*, 336-341.

[2]. Z. P. Han, M. M. Xu, R. Y. Zhang, X. P. Xu and S. J. Ji, *Green Chem*. **2021**, *23*, 6337-6340.